

Estimated longevity of contemporary subcutaneous implantable cardioverter-defibrillators: Multicenter real-world data



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Introduction

The subcutaneous implantable cardioverter-defibrillator (S-ICD) has become an established alternative to the transvenous implantable cardioverter-defibrillator (ICD) and has been incorporated into international guidelines for the prevention of sudden cardiac death over the past decade.^{1,2} Device longevity is a critical aspect of ICD therapy, yet contemporary data on the performance of current S-ICD models are limited. Early reports largely reflect first-generation devices,^{3,4} which differ from those in current practice owing to progressive design improvements and the resolution of a previous advisory on premature battery depletion.⁵ As implantation volumes increase, real-world data from modern S-ICD systems are now emerging. Remote monitoring platforms, in particular, provide an opportunity to capture device performance over time.

In this study, we evaluated the longevity of contemporary S-ICD generators and the factors influencing battery performance in a multicenter cohort followed through remote monitoring.

KEY FINDINGS

- Contemporary subcutaneous implantable cardioverter-defibrillators (ICDs) (S-ICDs) demonstrate an estimated median longevity of approximately 9 years in real-world clinical practice, exceeding manufacturer projections.
- The estimated S-ICD battery longevity is consistent over time.
- Telemetry-related energy consumption from remote monitoring and in-office interrogations has a negligible impact on overall device lifespan.
- Frequent shock delivery is associated with a reduction in longevity, whereas most patients experience minimal battery depletion over time.
- The observed longevity of modern S-ICDs approaches that of contemporary transvenous ICD systems, supporting their durability in routine practice.

KEYWORDS Subcutaneous implantable cardioverter-defibrillator; Device longevity; Battery depletion; Remote monitoring; Real-world data (Heart Rhythm 02 2026;7:790–793)

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Methods

Data for this study were sourced from implanted S-ICD EMBLEM devices (Boston Scientific Inc) that transmit information via the LATITUDE remote

monitoring system. In April 2025, we accessed the LATITUDE database to collect data on all S-ICD devices continuously monitored across 24 Italian centers between 2015 and 2025. The acquired deidentified patient data encompassed the status of arrhythmia detection and therapy parameters at the latest transmission, frequency of scheduled transmissions, logs of all in-office interrogations, remote transmissions, atrial fibrillation episodes detected, and details of administered shocks during the entire observation period from enrollment to the latest data transmission. Moreover, the value of remaining battery life automatically calculated by the device at the latest transmission was retrieved. Data from devices with <3-month implant duration (time since S-ICD implantation) were excluded. In this analysis, device longevity is provided as time since device’s implantation + estimated remaining battery life. Longevity estimates reflected generator battery performance and were not affected by device explantation for non–battery-related clinical indications. Patients enrolled in the LATITUDE monitoring system in Europe provide their consent to data storage. This analysis was conducted within the framework of the MULTITUDE registry ([ClinicalTrials.gov](https://clinicaltrials.gov) ID NCT06311149), an independent registry of patients managed with the LATITUDE system, aimed at analyzing and describing the clinical practice of remote cardiac implantable electronic device monitoring in Europe. The study reported in this paper adhered to the Declaration of Helsinki and was approved by institutional review boards.

Descriptive statistics are presented as medians with the interquartile range (25th–75th percentile), whereas categorical variables are expressed as percentages. Differences were compared by means of Mann–Whitney nonparametric tests for non-Gaussian variables. Event rates were represented as events per patient-year by calculating the ratio between the event counts during these phases and their respective follow-up durations. Time-to-event analysis used the Kaplan–Meier method. Multiple linear regression was used to identify variables associated with device longevity. Statistical correlations between variables were tested by means of linear regression analysis. $P < .05$ was considered significant for all tests. All statistical analyses were performed by means of R: a language and environment for statistical computing (R Foundation for Statistical Computing).

Results

Data from 2130 patients with S-ICDs enrolled in the LATITUDE remote monitoring network across 24 centers (2015–2025) were retrieved. A total of 241 devices were excluded owing to the safety advisory on possible premature battery depletion (issued August 2019), and 176 were excluded for time since device’s implantation of <3

Table 1 S-ICD and remote monitoring programming and the number (and percentage) of devices with shocks and episodes detected during the observation period from enrollment to the latest data transmission

Device parameter	N = 1713
Shock zone cutoff rate (beats/min)	250 (240–250)
Conditional zone cutoff rate (beats/min)	210 (200–220)
Postshock pacing ON, n (%)	1542 (90)
Gain 2×, n (%)	195 (11)
Sensing vector	
Primary, n (%)	953 (56)
Secondary, n (%)	613 (36)
Alternate, n (%)	147 (9)
Reverse shock polarity, n (%)	131 (8)
SMART Pass ON, n (%)	1573 (92)
Remote monitoring transmissions per year, n (%)	
≤3	66 (4)
4 or 6	769 (45)
12	288 (17)
>12	590 (34)
Shocks and episodes during the observation period	
In-office interrogations per year, n	2.1 ± 1.4
Shocks per year, n (%)	
0	1404 (82)
<1.0	204 (12)
≥1.0 and <2.0	63 (4)
≥2.0	42 (2)
Atrial fibrillation episodes per year, n (%)	
0	1075 (63)
<1.0	181 (11)
≥1.0 and <2.0	83 (5)
≥2.0	374 (22)

S-ICD = subcutaneous implantable cardioverter-defibrillator.

months. The final cohort included 1713 devices, with a median follow-up from implantation to the latest remote transmission of 2.7 years (25th to 75th percentile 1.5–4.1 years).

S-ICD programming characteristics from the most recent transmission are presented in [Table 1](#). Scheduled device transmissions occurred at least monthly in 51% of patients. During follow-up, an average of 2.1 ± 1.4 in-office interrogations per year were performed. Shocks were delivered to 309 patients (18%), corresponding to an incidence rate of 19.6 episodes per 100 patient-years (25th to 75th percentile 18.4–20.9). Episodes detected as atrial fibrillation were reported in 638 patients (37%), with an incidence of 8.0 episodes per patient-year (25th to 75th percentile 7.9–8.1).

At the most recent remote transmission, the estimated remaining battery life was 68% ± 19%. Remaining battery life was strongly inversely correlated with time since device’s implantation ($r = -0.99$; 95% CI, -0.99 to -0.98 ; $P < .001$) ([Supplemental Figure 1](#)). The overall median estimated device longevity was 9.0 years (25th to 75th percentile 8.7–9.2). Factors associated with

Table 2 Factors associated with S-ICD longevity

Factors	Coefficient	Standard error	P value
Shocks per year	−0.31	0.01	<.001
Postshock pacing ON	−0.10	0.05	.078
In-office interrogations per year	−0.05	0.01	<.001
Remote monitoring transmissions per year	−0.01	0.01	.018
Atrial fibrillation episodes per year	−0.01	0.00	.245

S-ICD = subcutaneous implantable cardioverter-defibrillator.

longevity are presented in [Table 2](#). The number of shocks delivered, in-office interrogations, and remote monitoring transmissions per year was all associated with shorter estimated device lifespan.

Patients experiencing ≥2 shocks per year had a 2-year reduction in estimated longevity compared with patients who received no shocks ([Figure 1](#)). By contrast, the impact of in-office interrogations and remote transmissions was minimal (<0.1 year). Devices with time since device’s implantation >6 years showed slightly shorter estimated longevity than those implanted for 1–2 years (8.9 years [25th to 75th percentile: 8.7–9.0] vs 9.3 years [25th to 75th percentile: 8.9–9.9]; *P* < .001).

Discussion

In this multicenter analysis, we found that contemporary S-ICDs offer an estimated longevity of 9 years, approxi-

mately 2 years longer than projected in the device manual.⁶ Battery life was mainly influenced by shock delivery and telemetry (in-office interrogations and remote transmissions). The effect of telemetry was negligible, whereas frequent shocks shortened longevity, reducing lifespan by approximately 2 years in patients with ≥2 shocks per year. Overall, these findings indicate that estimated S-ICD longevity is consistent over time and characterized by limited variability in clinical practice.

The S-ICD is an established alternative to the transvenous ICD, with comparable efficacy and a lower risk and easier management of major complications.^{7–9} Generator longevity remains a critical consideration, both clinically—owing to the need for surgical replacement—and economically—owing to the cumulative cost of device exchanges. Current transvenous ICDs demonstrate good performance, with single-chamber devices showing the longest lifespans, typically 7–12.5 years in clinical practice, whereas additional leads are associated with shorter duration.¹⁰ S-ICDs deliver higher-energy shocks and were expected to have shorter lifespans, with manufacturer-declared longevity up to 7.3 years under specific conditions ([Supplemental Material](#)). However, available real-world data have been inconsistent, often derived from earlier device generations or confounded by the 2019 advisory on premature battery depletion,^{3–5,11,12} which no longer applies to contemporary devices. Although contemporary transvenous ICDs are expected to have longer battery longevity than S-ICDs, comparisons based solely on projected lifespan are challenging owing to device heterogeneity and

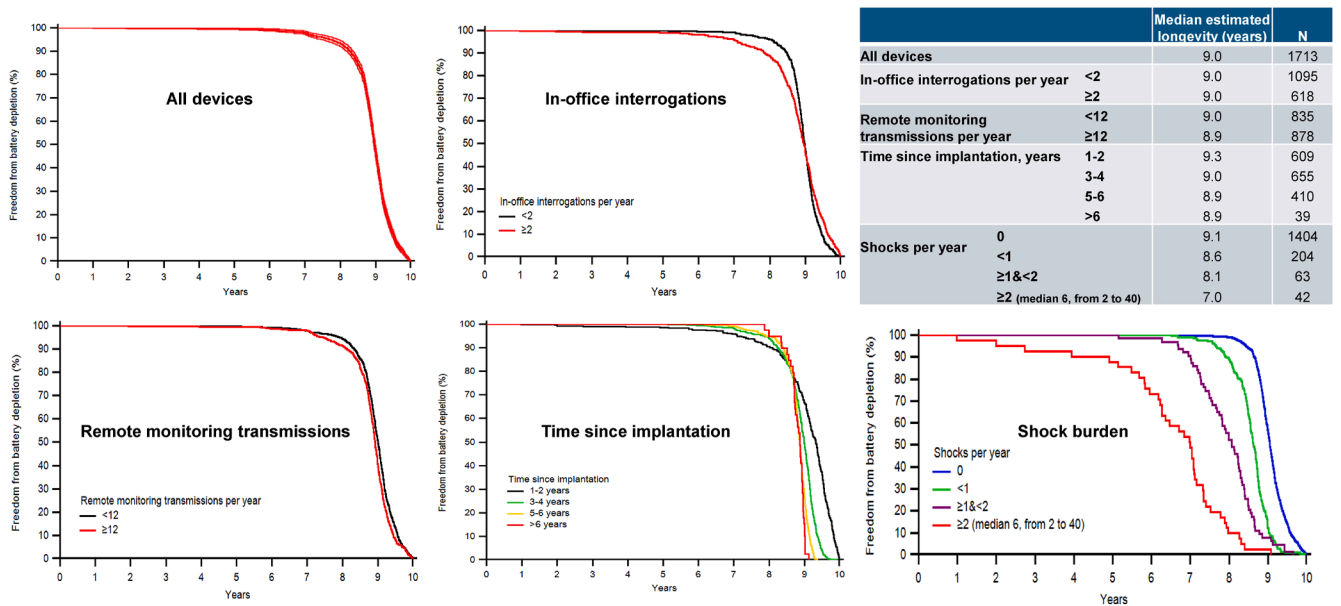


Figure 1 Longevity estimates (with confidence intervals) for all subcutaneous implantable cardioverter-defibrillators in analysis and for devices stratified by the number of in-office interrogations, remote monitoring transmissions, device implant duration, and shock burden. The table reports the median estimated longevity for all subgroups analyzed.

limited real-world follow-up for newer systems. Therefore, comprehensive cost assessments should account not only for generator longevity but also for differences in complication rates and long-term clinical outcomes.

Our findings are reassuring, demonstrating that modern S-ICDs exceed projected performance and approach the longevity range of transvenous systems.¹⁰ Importantly, estimated longevity was consistent across time since implantation and showed a strong correlation with follow-up time, suggesting the internal consistency of the longevity modeling. The predictability of S-ICD longevity is further reinforced by the fact that all estimates are generated with electrogram recording permanently active, thereby avoiding hidden sources of energy consumption. This approach aligns with proposed standardized reporting criteria for cardiac implantable electronic devices and facilitates fair comparisons across different platforms.¹³

The observed reduction associated with frequent shocks, although notable, reflects a subgroup with high shock burden and wide variability (median 6, from 2 to 40), as also suggested by the shape of the longevity curve. These results align with a previous analysis from remotely monitored S-ICDs,¹⁴ although that study was limited to US populations and included devices subject to premature depletion. By contrast, our analysis focuses on contemporary devices implanted in European clinical practice, providing complementary real-world evidence.

This study has limitations. Longevity was estimated rather than observed, unlike other reports,¹⁵ given that the current S-ICD family has only been available since 2015. Such constraints are common to analyses of evolving ICD technologies. Furthermore, the dataset was restricted to a single European country, limiting generalizability, and lacked clinical characteristics and outcomes that might influence device utilization. Longer follow-up and broader international datasets will be essential to confirm these findings and further refine predictors of device longevity.

Conclusion

Contemporary S-ICDs demonstrate an estimated longevity of 9 years, exceeding manufacturer expectations and approaching the range of transvenous ICDs. The estimated S-ICD battery longevity is consistent over time, with only minimal impact from telemetry and a clinically relevant reduction observed primarily in patients experiencing multiple shocks per year. These findings provide reassuring evidence of the durability of modern S-ICDs in routine clinical practice.

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

Ethics Statement: The study reported in this paper adhered to the Declaration of Helsinki and was approved by institutional review boards.

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

Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hroo.2026.01.020>.

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