

The Old Habits Need to be Abandoned and the Term “Overload” Replaced by “High Amplitude Criteria”

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Left ventricular overload?

Brazilian electrocardiograms (ECG) reports have long labeled voltage-positive tracings as “left ventricular overload,”¹ a legacy of historical teaching that linked hemodynamic loads to characteristic repolarization patterns.² The problem is not the physiology but the nomenclature: overload is a hemodynamic claim, whereas the ECG measures electrical phenomena. Contemporary evidence reframes voltage positivity as an electrical phenotype with variable correlation to left ventricular mass (LVM) and geometry. In this article, we argue that Brazil should retire “overload,” adopt “high-amplitude criteria” as the report label, and explicitly teach the underlying concept of left ventricular electrical remodeling (LVER), so that our language matches what the ECG actually measures.

Phrasing “left ventricular overload” feels pragmatic — if surface ECG is “insensitive” to anatomic hypertrophy, perhaps what it detects is something else, namely “overload.” The evidence base argues otherwise. Electrocardiography records electric fields at the body surface; it does not directly measure mass, geometry, or loading conditions. This distinction is the core of the modern paradigm articulated by Ljuba Bacharova et al.: QRS voltage and morphology reflect an interplay of spatial determinants (source geometry, torso conductivity, electrode distance) and non-spatial determinants (conduction velocity, intercellular coupling, fibrosis, ionic remodeling), such that the same LVM can yield different voltages — and high voltage can arise with normal mass — depending on the myocardium’s electrical properties.³ The Working Group’s “4th Report” in the *Journal of Electrocardiology* integrates mechanistic simulation studies with population data and draws three conclusions that are decisive for our terminology. First, increased LVM and geometric type (concentric, eccentric, dilation) are not the main or only determinants of QRS patterns; combinations of anatomy and slowed activation propagation produce

the observed spectrum from “pseudo-normal” tracings through high voltage and prolonged intrinsicoid deflection to left bundle branch block. Second, diffuse conduction slowing or midwall conduction abnormalities — without any increase in mass — can generate QRS changes that meet conventional electrocardiographic-left ventricular hypertrophy (LVH) criteria in a normal-sized ventricle. Third, in community cohorts the electrical and anatomic phenotypes frequently diverge, and each carries independent prognostic information.⁴

The mechanistic details are consistent. In simulations, imposing diffuse transmural slowing, or focal midwall slowing, shifted the electrical axis leftward and increased limb-lead voltages, reproducing classic electrocardiographic-LVH signatures even when ventricular size was normal; increasing the volume of slowed tissue amplified these effects.⁵ Introducing intramural electrically inactive regions surrounded by zones of slowed activation — an electrophysiologic analogue of ischemic injury — produced the expected infarction patterns but also increased R in aVL, left anterior fascicular block features, and voltage elevations classically read as “LVH,” underlining that electrical remodeling in ischemia can transiently mimic hypertrophy.⁶

In population data, the Multi-Ethnic Study of Atherosclerosis (MESA) compared cardiac magnetic resonance (CMR)–defined LVH and ECG criteria, dividing participants into concordant positives and negatives and into “false positive” (ECG+, CMR–) and “false negative” (ECG–, CMR+) strata. Outcomes separated cleanly: true positives had the worst prognosis (hazard ≈ 2.8 vs reference), “false negatives” carried intermediate risk (≈ 1.8), and “false positives” were not benign noise but exhibited risk indistinguishable from reference in some models and adverse in others depending on the endpoint — demonstrating that the electrical phenotype is not merely a measurement error of mass but a distinct marker of biology and risk.⁷ Finally, in ARIC, the Romhilt–Estes score predicted all-cause mortality over two decades; notably, P-terminal force in V1 and the ST-T “strain” pattern outperformed raw QRS amplitude, implying that repolarization and atrial conduction abnormalities — electrical remodeling, not mass per se — drive much of the prognostic signal.⁸ The Working Group concluded that calling discordant ECG results “false positives/negatives” is misleading: what we are observing is LVER, which may or may not accompany increased mass, and which can change with antihypertensive therapy and other interventions.^{9,10} LVH is a process, not a static state, and the relation between LV mass and QRS voltage changes across stages of remodeling. Experimental volume-overload data show a non-monotonic

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trajectory—QRS amplitude can decrease during developing hypertrophy, increase once hypertrophy is established, and decline again with progression toward failure—underscoring why single-timepoint amplitude cannot be interpreted as a simple surrogate for mass or geometry.¹¹ Framed by the solid-angle theorem, both spatial and non-spatial determinants evolve over time; disagreement between electrocardiographic-LVH and imaging at a given visit may therefore reflect stage, not error.¹²

These data also argue against a binary reading of voltage. Looking ahead, replacing this habit with ordinal, percentile-anchored voltage bands may be a logical next step. Report as “possibly absent/possibly present/probably present” bands that map to empiric post-test probabilities of anatomic LVH and to outcomes. We are developing and validating calibrated voltage criteria; until these tools are peer-reviewed, we recommend descriptive grading to communicate uncertainty while avoiding anatomic claims. For example, Sokolow–Lyon values in the mid-30s versus the mid-40s imply different post-test probabilities even though either can occur with normal mass. Voltage criteria do not separate geometric patterns. In a Brazilian cohort comparing ECG against echocardiography, Sokolow–Lyon, Cornell, and Peguero–Lo Presti amplitudes were essentially identical in concentric versus eccentric LVH, despite large differences in relative wall thickness; median values and distributions overlapped with no significant between-group differences.¹³

Together, these data explain why “overload” is the wrong label. “Overload” is a hemodynamic inference (pressure vs volume) best adjudicated by imaging and invasive or Doppler hemodynamics. ECG gives us an electrical phenotype whose mechanistic drivers include conduction velocity, coupling, fibrosis, fiber orientation, and ischemia — variables that frequently decouple from mass and geometry and that alter risk through arrhythmic and pump-failure pathways.¹⁴ Invasive data underscore the point: in severe aortic stenosis, classic voltage criteria discriminate invasive filling pressures only modestly: for left ventricular end-diastolic pressure >15 mm Hg, areas under the curve (AUCs) were 0.61 (Sokolow–Lyon), 0.59 (Cornell), 0.56 (Romhilt–Estes), and 0.62 (Peguero–Lo Presti); for mean pulmonary artery wedge pressure >15 mm Hg, AUCs were 0.62, 0.60, 0.59, and 0.62, respectively; and for pulmonary vascular resistance >2 WU, performance hovered near chance (AUC 0.53–0.56).¹⁵ Voltage is therefore a weak surrogate for hemodynamic “overload,” which should be established by imaging or catheterization.

Terminology note: We recommend “high-amplitude criteria” as the standardized report label for voltage-positive QRS (an electrical phenotype, not an anatomic diagnosis). Mechanistically, this phenotype reflects LVER — changes in conduction, coupling, fibrosis, and repolarization that may occur with or without increased mass. In Portuguese, use “critérios de alta amplitude” (fenótipo elétrico) as the reporting label and “remodelamento elétrico do ventrículo esquerdo” for explanatory text.

Although right ventricular hypertrophy (RVH) is not the focus of this report, ECG findings in the right precordial leads (V1–V3) show even poorer agreement with anatomic/

hemodynamic RV hypertrophy than left-sided indices.¹⁶ We recommend the same convention used for the left ventricle: report high-amplitude criteria (right precordial leads) — an electrical phenotype — rather than inferring “right ventricular overload.”

Implications for Brazilian practice

If we accept that “high amplitude criteria” denotes an electrical phenotype, two changes follow for Brazil: we should change how we name the finding and how we teach it. Reports that currently read “left ventricular overload” should instead read “high-amplitude criteria”, an electrical phenotype with limited correlation to anatomic LVH, and they should add a one-line clarifier every time amplitude criteria are met: “Voltage positivity reflects an electrical phenotype that may occur with or without increased LV mass; imaging is required to confirm anatomical hypertrophy.” This wording is faithful to the evidence summarized above and mirrors modern consensus documents that separate anatomic from electrical remodeling.¹⁴ It also removes an implicit hemodynamic promise embedded in “overload.” Pressure and volume overload remain clinically vital constructs, but they should be named when they are measured (by echocardiographic geometry and hemodynamics), not when they are inferred from a surface potential map (Table 1).

Updating the lexicon must be paired with updating our pedagogy. Residency and fellowship curricula should foreground the solid-angle intuition and the non-spatial determinants of voltage and repolarization, using the Working Group’s simulations as teaching figures: show that increased midwall conduction delay alone can satisfy electrocardiographic-LVH thresholds; show that ischemic injury patterns can transiently “raise voltage” and shift the axis; and show that adding mass without electrical remodeling can leave voltage near-normal.⁵ Teach why “threshold tinkering” — for example, Youden-optimizing Sokolow–Lyon, Peguero–Lo Presti or Cornell cutoffs — cannot rescue sensitivity in a signal whose variance is dominated by tissue electrical properties and body habitus; this is now clear across cohorts, including analyses in MESA that demonstrate minimal diagnostic gains even when thresholds are re-fit and combined.¹⁷ Most importantly, emphasize why the ECG remains indispensable despite its diagnostic limits for mass: because electrical LVH (or LVER) forecasts outcomes independently of anatomy and may respond to therapies that remodel conduction and repolarization, not only those that regress mass.^{10,18,19} Teaching should emphasize graded interpretation of amplitude and the distinction between electrical and anatomic signals; “threshold tinkering” cannot rescue sensitivity when variance is dominated by tissue electrical properties and body habitus.

Anticipated objections are addressable within the text of the report itself. Some will argue that “overload” is less misleading than “hypertrophy.” That inference only holds if every reader understands “overload” as code for “voltage-positive ECG,” which they do not; the term suggests a specific hemodynamic state the ECG cannot establish. Similarly, some may note that complementary imaging is routinely ordered regardless of ECG terminology, making

Viewpoint

Table 1 – Standardized ECG report text for LVH terminology

Term (EN)	Abbrev.	Term (PT-BR)	Definition	When to use in reports
High amplitude criteria	—	<i>“Critérios de alta amplitude” or “critérios de amplitude”</i>	Voltage-positive QRS by legacy criteria (e.g., Sokolow–Lyon, Cornell, Peguero–Lo Presti). Denotes an electrical phenotype with limited and variable correlation to anatomic LVH.	As the base label whenever amplitude criteria are met; append the clarifying clause about correlation and imaging.
Left Ventricular Electrical Remodeling	LVER	<i>Remodelamento elétrico do ventrículo esquerdo (REVE)</i>	Mechanistic construct: changes in conduction, coupling, fibrosis, and repolarization that shape QRS amplitude/morphology with or without increased LV mass.	In explanatory text (not as the formal report label) to interpret ECG–imaging concordance/discordance and to guide management discussion.

Suggested standardized phrases for ECG reports to replace “left ventricular overload” terminology. The base report line should be used whenever amplitude criteria are positive. ECG: electrocardiograms; LVH: left ventricular hypertrophy.

the label clinically inconsequential. However, the report label shapes the pre-test framing of that imaging request and influences whether discordant results are dismissed as ‘false’ or interpreted as independent prognostic. Using “high amplitude criteria” and a one-sentence clarifier is more transparent and scientifically sound. Others may worry that the “electrical phenotype” sounds abstract and might confuse patients. A short plain-language addendum solves this without sacrificing accuracy: “This electrical pattern can occur with or without LVH; echocardiography or cardiac MRI is needed to measure heart size.” Finally, some fear that changing reports will confuse clinicians. Our objective is explicit: anatomical LVH and electrical LVH are different but complementary manifestations of remodeling; discordance is expected; and discordant results often carry distinct prognostic information that should be leveraged rather than dismissed as “false”.⁴ We acknowledge that displacing entrenched terminology is difficult and that medicine tolerates many semantic imprecisions (e.g., ‘extrasystole’ for non-interpolated premature beats). Yet when imprecision encodes a hemodynamic inference the method cannot support, the cost is anchoring clinical reasoning to a physiologic claim — pressure or volume overload — that may be absent.

Brazilian cardiology can lead by example here. We can train our residents to recognize that high voltage is a biomarker of conduction and tissue properties as much as of mass; and that risk stratification improves when we read the ECG on its own terms and confirm anatomy with imaging when it matters. We recognize that terminology adoption is incremental; the immediate, actionable step is the one-line clarifier appended to every voltage-positive report, which can coexist with legacy labels during a transition period.

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Use of Artificial Intelligence

During the preparation of this work, the author(s) used ChatGPT to make language edits and improve clarity in English. After using this tool/service, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

Data Availability Statement

The underlying content of the research text is contained within the manuscript.

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