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EASI Monitoring: An Alternative to Conventional Electrocardiography in the Recording of Ventricular Tachycardia

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Abstract

This study compares the EASI monitoring setting with the conventional 12-lead electrocardiogram (ECG) in patients experiencing ventricular tachycardia (VT) episodes. The results revealed that the EASI monitoring setting demonstrated a VT morphology that closely resembled that of the conventional ECG in the majority of cases. This finding suggests that EASI monitoring could serve as a valuable alternative in situations where obtaining a conventional ECG is either risky or not feasible.

Keywords: Electrocardiography, Ventricular tachycardia, Ablation techniques, Electrophysiology, EASI

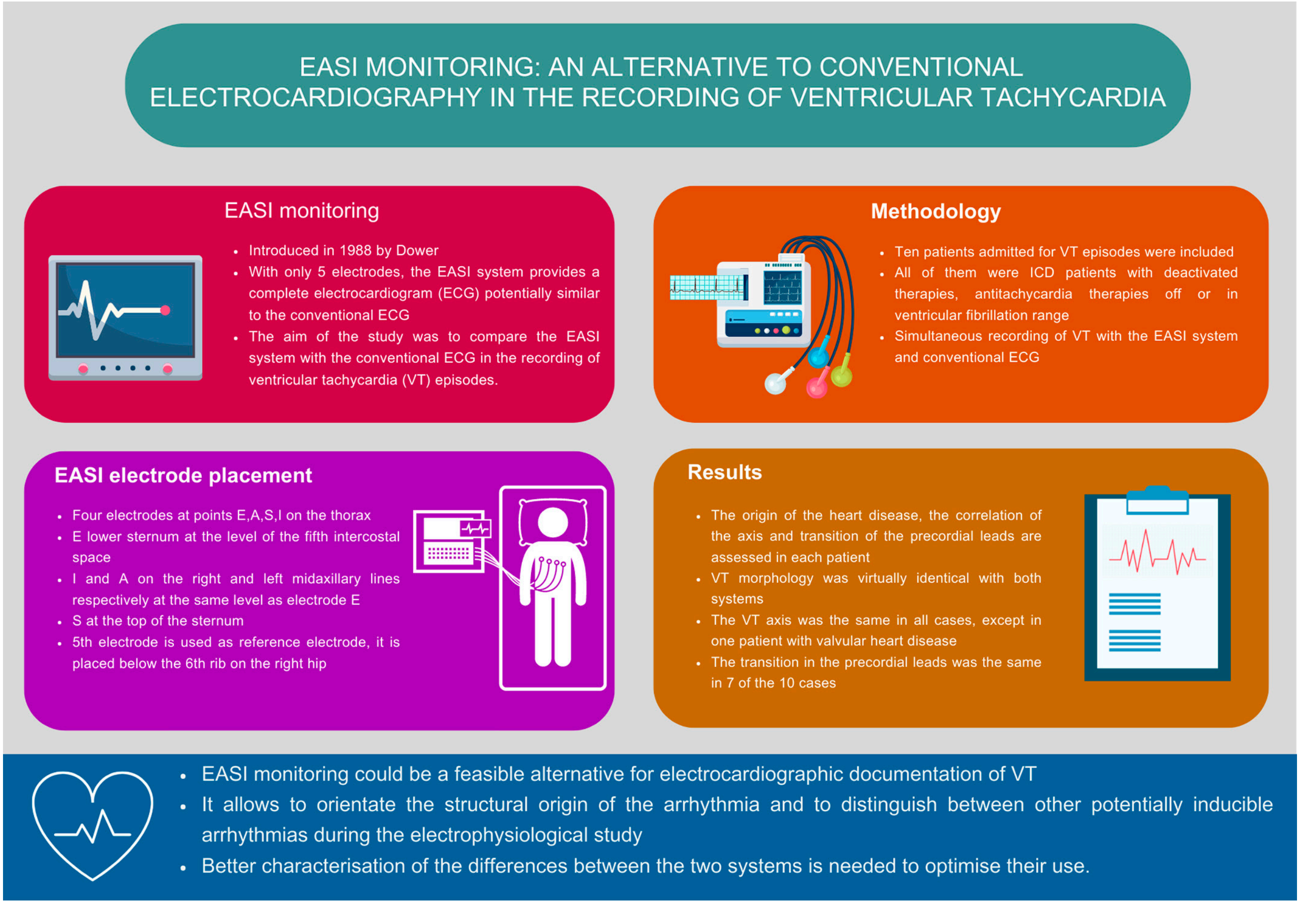
Abbreviations: ECG: Electrocardiogram; VT: Ventricular Tachycardia; ECG-12: 12-lead ECG; EPS: Electrophysiological Studies; CCU: Critical Care Units; ICDs: Implantable Cardioverter-Defibrillator

Introduction

Electrocardiographic monitoring plays a crucial role in diagnosing and treating patients with cardiac disorders. Conventional electrocardiography technique has been widely employed for years to identify arrhythmias, myocardial ischemia, and other cardiac abnormalities. However, this technique has limitations when it comes to continuous monitoring due to its technical complexity and the requirement for multiple leads.

In this regard, the EASI configuration, introduced by Dower in 1988 [1], emerges as an alternative in acute cardiology patients. With only five electrodes, the EASI system enables the acquisition of a comprehensive electrocardiogram (ECG) that is potentially comparable to a conventional ECG, making it particularly valuable in emergency situations.

Documenting ventricular tachycardia (VT) on a 12-lead ECG (ECG-12) is vital for guiding ablation strategies, as it helps determine the origin of the VT and differentiate it from other potentially inducible VTs during electrophysiological studies (EPS) [2]. Patients experiencing VT are admitted to Critical Care Units (CCU) and undergo monitoring to capture such events. Typically, an ECG-12 of VT is obtained during monitoring in the CCU. Consequently, dual monitoring is usually employed,



involving customary monitoring and the use of conventional ECG leads. This dual monitoring necessitates deactivating anti-tachycardia therapies in patients with implantable cardioverter-defibrillators (ICDs) and delays the initiation of therapies to terminate the arrhythmia until the VT has been electrocardiographically documented. This delay may pose a significant risk, particularly when VT is poorly tolerated hemodynamically or may even prevent the documentation of the arrhythmia if immediate defibrillation is required. Moreover, the limitations imposed on the patient's movement due to the ECG-12 electrodes introduce additional discomfort and potential complications.

Given the aforementioned challenges, the objective of this study is to compare the utility of the EASI configuration with ECG-12 in VT patients.

Methods

Ten consecutive patients, admitted to the CCU of a tertiary hospital, for VT episodes were included in this study. At least one VT episode was documented for each patient. The principal aim of this investigation was to systematically record and analyze the electrocardiographic features of each VT through the utilization of an ECG-12, specifically in the context of guiding VT ablation interventions. Each patient included in this study had an implantable cardioverter-defibrillator (ICD), with anti-tachycardia modalities either deactivated or functioning solely in the case of ventricular fibrillation events. This particular approach was implemented as an integral component of the non-pharmacological methodologies directed at the comprehensive characterization and elucidation of VT patterns [3].

Informed consent was obtained from all patients prior to their participation. Upon admission, the patients underwent monitoring using an ECG-12 following the Mason-Likar arrangement [4]. This configuration allows for greater patient mobility and comfort. Several aspects of this lead placement configuration for recording a 12-lead ECG are noteworthy. The QRS complexes of the limb leads are slightly different in amplitude when the limb leads are repositioned on the torso. Precordial leads may also vary slightly when using the central Wilson lead as an indifferent electrode, which is composed of the LA, RA, and LL leads [5]. These aspects are not decisive in identifying the origin of the ventricular tachycardia.

Simultaneously, bedside monitoring was conducted using the EASI configuration. For the EASI monitoring, four electrodes were strategically placed on the patient's chest at specific locations: electrode E was positioned on the lower sternum at the fifth intercostal space, while electrodes I and A were placed on the right and left midaxillary lines, respectively, at the same level as electrode E. Electrode S was positioned on the upper part of the sternum. The fifth electrode served as a reference and was typically placed below the sixth rib on the right hip. This electrode placement allowed for a more comprehensive perspective of the heart's electrical activity from different angles and minimized interference and noise in the ECG signals. It is worth noting that precise electrode placement is crucial for accurate electrocardiographic monitoring and reliable diagnostic outcomes.

The EASI monitoring system automatically performed a mathematical transformation of the data acquired from the four electrodes to generate a complete 12-lead image. ECGs were simultaneously recorded using both the EASI system and the ECG-12. Due to a conflict in the position of electrode V6 and electrode A in the EASI system when placed on the mid-axillary line, the V6 electrode was positioned 2 cm toward the anterior axillary line, right next to electrode A [6]. All electrocardiograms were recorded at a speed of 25 mm/s and calibrated with 10 mm=1 mV.

Results

Given the descriptive nature of the study and the objective of comparing the morphology and electrocardiographic pattern of ventricular tachycardia documented with both systems, the results obtained only addressed the polarity (positive or negative) of the QRS in the different leads of both the ECG-12 and the EASI system, including the axis correlation and the transition in precordial leads. We also recorded the type of cardiomyopathy and, if an electrophysiological study/ablation had been performed and the VT was inducible, the point of origin of the tachycardia. Case by case description is included in **Table 1**.

Table 1. Comparison of conventional 12-lead ECG and EASI.

Heart disease	Morphology of ECG-12 limb leads	Morphology of EASI limb derivations	Precordial transition ECG-12	Precordial transition EASI	Ablation
Non-ischemic	+ I, II, III, aVF - aVR, aVL	+ I, II, III, aVF - aVR, aVL	V3	V3	Right ventricular outflow tract
Ischemic	+ I, II, III, aVR, aVL - aVR	+ I, II, III, aVR, aVL - aVR	V2	V2	Right sinus of Valsalva
No heart disease	+ I, II, III, aVF, aVL - I, aVR, aVL	+ I, II, III, aVF, aVL - I, aVR, aVL	Negative concordance	Negative concordance	Non-inducible in EP**
Valvular	+ I, II, III, aVF, aVL -aVR	+ I, II, III, aVF -aVR, aVL	V4	V3	Not done
Non-ischemic	+ aVR -I, II, III, aVF, aVL	+ aVR -I, II, III, aVF, aVL	V6	Positive concordance	Inferolateral epicardial substrate ablation
Ischemic (HM III*)	+ aVR - I, II, III, aVF, aVL	+ aVR - I, II, III, aVF, aVL	V4	V4	Not done
Alcoholic Cardiomyopathy	+ II, III, aVF - I, aVR, aVL	+ II, III, aVF - I, aVR, aVL	Positive concordance	Positive concordance	Surgical epicardial cryoablation, mesocardial alcohol ablation
Ischemic	+ II, III, aVF - I, aVR, aVL	+ II, III, aVF - I, aVR, aVL	V4	V4	Extensive anterior and apical substrate ablation
Chagas	+ II, III, aVF -I, aVR, aVL	+ I, II, III, aVF - aVR, aVL	Positive concordance	V4	Epicardial origin, not ablation
Ischemic	+aVR, -I, II, III, aVF, aVL	+aVR, -I, II, III, aVF, aVL	V5	V5	Substrate ablation pending

*HM III: Heart Mate III; ** EP: Electrophysiological study

The axis of VT, determined by the polarity of the QRS in the limb leads, was observed to be the same in all cases (**Figure 1**), except for the patient with valvular heart disease, where a difference in QRS polarity in lead aVL was observed between the two recording systems. This patient experienced incessant bouts of non-sustained VT.

Regarding the transition in the precordial leads (lead in which the QRS polarity changes from positive to negative or vice versa), it was consistent in both recording systems for 7 out of 10 cases. In 2 of the remaining 3 cases where a difference in transition was observed, the origin of VT was determined to be in the epicardium in the EPS performed: one of them with non-ischemic dilated cardiomyopathy of unknown origin (successful epicardial ablation, VT originating from the inferolateral segment of the LV). The second case involved a patient with chagasic cardiomyopathy in whom ablation was not performed due to the induction of multiple VTs that were different from the clinical presentation. This electrophysiological peculiarity can be explained by the delay of the electrical impulse until it reaches the endocardium, resulting in an initially blunted QRS complex in the precordial leads [7]. In the third one in which transition missed, a patient with valvular heart disease (non EPS performed), QRS had a slightly negative RS morphology in ECG-12 and positive Rs by EASI.

A notable case was a patient with a HeartMate III ventricular assist device, where despite the altered cardiac anatomy and artifacts produced by the left ventricular assist device [8], the ECGs obtained by both systems were virtually identical in terms of VT morphology (**Figure 2**).

Discussion

Accurate electrocardiographic documentation of VT is crucial for successful ablation procedures, particularly in patients with non-ischemic heart disease where the arrhythmogenic substrate may be more complex and diverse [9,10]. The findings of this study provide evidence that the EASI system could serve as a valid alternative in situations where obtaining an ECG-12 is risky or not feasible.

In clinical practice, the EASI system can offer several advantages. Firstly, it allows for a complete 12-lead ECG to be obtained with only 5 electrodes, reducing the complexity and time required for electrode placement. This is particularly beneficial in emergency situations where rapid and efficient monitoring is essential. Additionally, this 5-electrode monitoring system minimizes interferences and noise in the ECG signals.

The use of the EASI system can also alleviate the need for dual monitoring, where both conventional ECG leads and the usual monitoring, are simultaneously employed, leading to improved patient comfort and safety. Moreover, in cases

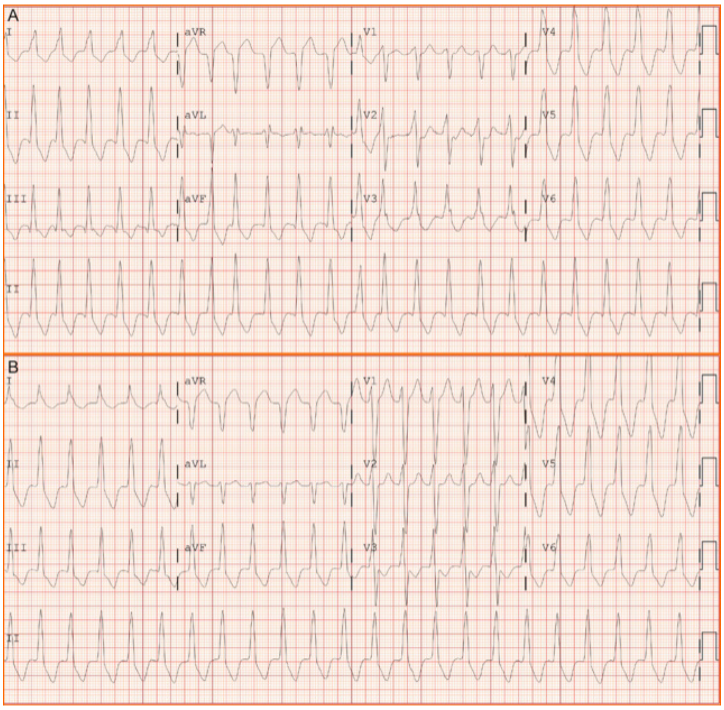


Figure 1. Ventricular tachycardia of the right ventricular outflow tract. **Panel A**, electrocardiographic recording with the EASI system. **Panel B**, electrocardiographic recording with conventional electrocardiogram.

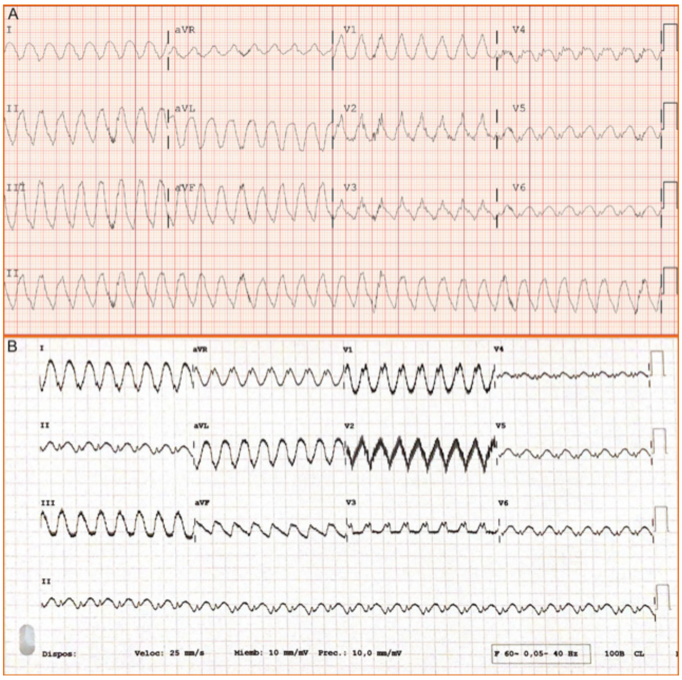


Figure 2. Ventricular tachycardia in patient with HeartMate III ventricular assist device originating in the area surrounding the inflow cannula implant. **Panel A**, electrocardiographic recording with the EASI system. **Panel B**, electrocardiographic recording with conventional electrocardiogram.

where VT is poorly tolerated, the time saved in obtaining the recording with the EASI system may prevent adverse events such as shock or cardiorespiratory arrest.

Limitations

This study has several limitations, including the small sample size and the observational nature of the research. Additionally, it is crucial to recognize certain constraints related to the EASI system. Accurate electrode placement is vital to ensure precise monitoring and dependable diagnostic results. Any deviations or errors in electrode positioning can impact the quality and interpretation of the electrocardiographic signals. Therefore, rigorous training and adherence to proper placement techniques are imperative when utilizing the EASI system. Importantly, it was not feasible in all cases to confirm the origin of ventricular tachycardia through electro-anatomical mapping.

Conclusions

EASI monitoring represents a promising alternative for documenting VT when conventional 12-lead ECG is challenging to perform. This alternative allows for precise identification of the structural origin of the arrhythmia and differentiation from other potentially inducible arrhythmias during electrophysiological studies, thereby facilitating ablation procedures. A more comprehensive characterization of the distinctions between the two monitoring systems is warranted to optimize their application. It is important to emphasize that this study is descriptive in nature and features a limited sample size. Consequently, further research involving a larger patient cohort is required to validate and expand upon these findings.

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Author contribution

Conceptualization: MBS, GLAS; Resources: MBS, LPA, MCAL, JGM, ATS, NPR, PRS, and MIMG; Software: MBS, MCAL, GLAS; Investigation: GLAS; Methodology: MBS, GLAS; Writing-original draft: MBS, MCAL, GLAS; Writing-review & editing: MBS, LPA, MCAL, JGM, ATS, NPR, PRS, MIMG and GLAS; Project administration: GLAS.

Ethics

The study received approval for its conduct from the Institutional Review Board. All patients consented to participate.

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