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Study Library

Derived 12-lead electrocardiograms registrated by a simplified 3-lead setting using 4 electrodes

The 12-lead electrocardiogram (ECG) is the worldwide electrocardiographic gold standard for the detection of myocardial ischemia and is recommended in all guidelines from national and international cardiovascular societies. The 12 leads are usually derived from 10 electrodes. The EASI standard is a method of recording an ECG that is an alternative to the traditional 10-electrode Mason-Likar 12-lead ECG system. The EASI lead configuration enables a 12-lead ECG using only 5 electrodes. The EASI 12-lead ECG is derived from this reduced lead set using a method described by Dower et al. [1-3]. The EASI 12-lead ECG is derived from a set of 5 leads: 4 recording electrodes and one grounding electrode. The agreement between the EASI ECG and the standard 12-lead ECG for the detection of acute myocardial ischemia has been shown in many reviewed studies [4-18].

The CardioSecur system additionally eliminates the grounding electrode, allowing the registration of a derived 12-lead ECG from 4 electrodes. The agreement of the modified CardioSecur setting has been clinically proven and published ["Comparison of standard and derived 12- lead electrocardiograms registrated by a simplified 3-lead setting with four electrodes for diagnosis of coronary angioplasty-induced myocardial ischemia"; 17].

Intra-individual ECG-Comparison
CardioSecur offers the highest possible sensitivity for myocardial ischemia by comparing the actual ECG with a previously recorded reference ECG. When first using the CardioSecur system, the user records a reference measurement of the ECG. Any other following measurements compare the actual ECG with the individual's reference ECG. This intra-individual comparison allows for detection of ECG changes, even when preexisting complex ECG changes are present (left bundle branch block, ST deviation, ECG after previous myocardial infarction.
The serial use of the CardioSecur system even allows for detection of so-called silent myocardial ischemia in patients without symptoms.

ECG algorithms

CardioSecur algorithms detect changes in the ECG of heart rate, rhythm and circulation (indicating myocardial ischemia). The algorithms are completely based on the recommendations of the cardiovascular societies and standards. The sensitivity of the algorithm has been shown in an internal validation study including more than 120,000 ECGs based on a normatively standardized ECG database. The current national and international cardiovascular guidelines for the ECG diagnosis of the ST segment elevation acute myocardial infarction (STEMI) require at least 1 mm (0.1 mV) ST segment elevation in the limb leads, and at least 2 mm elevation in the precordial leads. These elevations must be present in anatomically contiguous leads (I, aVL, V5 and V6 correspond to the lateral wall; V1-V2 correspond to the septal wall; V3-V4 correspond to the anterior wall; II, III, aVF correspond to the inferior wall) [21]. Moreover, the algorithms include absolute and relative changes of the ECG. The intra-individual ECG comparison offers the

opportunity to detect changes of the ECG that have pseudo normalized - especially of the ST segment and the T waves.

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1. Comparison of Standard and Derived 12-lead Electrocardiograms Registrated by a Simplified 3-Lead Setting with Four Electrodes for Diagnosis of Coronary Angioplasty-induced Myocardial Ischaemia

European Heart Journal, 2012 1(7): 185, European Cardiology, 2012; 8(3): 179

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Personal MedSystems GmbH

Background
Electrocardiograms, (ECG) derived by the transformation of three bipolar quasi-orthogonal leads, have according to EASI been introduced for many years for use in emergency situations and for the monitoring of patients during the acute phase of myocardial infarction. Theoretically, a further reduction and simplification of the classic EASI setting of five electrodes may even improve acceptance of the derived 12-lead ECG in these critical situations, especially in the telemedical use and for monitoring of cardiovascular patients. The objective of the present study was to evaluate the comparability of the 12-lead ECG derived by a system that reduces the classic EASI setting from five to four electrodes with the standard 12-lead ECG in the detection of acute myocardial ischemia induced during percutaneous transluminal coronary angioplasty (PCI).

Methods
To determine whether a 12-lead ECG derived from a reduced EASI setting using only four electrodes would demonstrate typical ST-segment changes of ischemia during percutaneous coronary intervention (PCI); 24 patients with overall 148 episodes of balloon-induced myocardial ischemia were monitored with continuous 12-lead ST-segment monitoring during PCI. Additionally a derived 12-lead ECG was registrated by the four electrodes system. Two blinded cardiologists, not involved in the intervention, compared both ECGs for each patient.

Results
Of the 148 episodes of balloon inflation recorded with the derived ECG, 104 (70.3 %) were associated with typical and significant ischemic ST-segment changes during balloon inflation. The amplitudes of these ST deviations were similar to those observed during transient myocardial ischemia observed in clinical settings (median peak ST deviation, 234 microV). There was an agreement regarding presence or absence of ischemia in 147 of the 148 episodes of ischemia recorded, with both derived and standard electrocardiographic methods (>99 % agreement). Withuse of the standard ECG as the 'gold standard' for ischemia diagnosis, there was no false-negative result (0 %) and only one false-positive result (0.7 %) with the derived ECG.

There was no significant difference between the two techniques by linearity tests ($p>0.1$). Bland–Altman analysis showed no significant bias. Moreover, both methods demonstrated 100 % concordance with respect to localization of myocardial ischemia (anterior, inferior and lateral).

Conclusions

The new four electrodes set 12-lead ECG is as an alternative to the standard 12-lead ECG with 10 electrodes in emergency situations and for monitoring of cardiovascular patients.

Comparative study of the CardioSecur pro ECG system with the EASI Philips M2601B

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Aim of the Study

A comparative study was conducted to validate the ECG measurements of CardioSecur. CardioSecur is a tablet-based ECG system using 4 electrodes to derive a 22-channel ECG (standard 12-leads + V7-V9 and VR1-VR9). The technology of CardioSecur is based on the calculation of 12 leads gained from 4 electrodes and these are comparable to the standard 12 lead ECG.

Figure 1: Electrode Placement and technical components of CardioSecur

Methods

To assess both the technical and the medical comparability of the systems, the setup was divided into two procedures, the first test covering the medical diagnostic accuracy of the two systems, the second test covering the technical comparability of the ECG signal, generated with the reduced lead system. In the first test ECG measurements were taken from 41 individuals with both systems. A clinical diagnosis was made on these ECGs by two independent cardiologists and the orientation of the waves P, R, T and S were evaluated and compared. To assess the technical waveform of the two systems, ECGs were simulated with an ECG simulator to ensure identical electrical input on both systems. These ECGs were simulated at frequencies between 30 and 180bpm. Additionally, pathological ECG patterns were simulated and recorded with the systems. These waveforms were compared with respect to morphology and height of the electrical signal in the standard 12 leads of the two systems.

Results

The clinical diagnosis for 41 measured patients was identical in the ECGs measured with both CardioSecur and Philips M2601B. These diagnoses included a variety of clinical patterns including rhythm disorders, acute MI and old MI. A paerson correlation coefficient was calculated for CardioSecur and Philips for the classical 12 leads and was high for all measured parameters (see table 1). The additional 10 leads of CardioSecur were not analyzed as part of the study as the Philips device does not offer this option.

The second test, covering a technical analysis including waveforms and peak heights of simulated ECGs, revealed differences in the heights of the R- and S-wave. CardioSecur showed an absolute R peak 10% higher than the Philips device (see figure 2). This difference can be explained by the use of different filter settings in the devices. The Philips M2601B clearly states that the recorded ECG may not be used for ST-segment evaluation. CardioSecur uses a filter setting compliant with the regulatory standards to allow ST-segment evaluation. Consequently, a difference in absolute peak height can be also seen in figure 3. Morphologically, all ECGs (patient and simulated) showed identical orientation of the measured parameters.

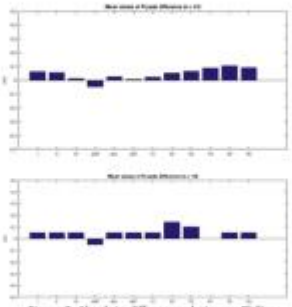

Figure 2: Absolute differences between Philips and CardioSecur in R-Peak amplitude.

Leads	R-peak	S-peak	ST-segment
I	0,99	0,99	0,94
II	0,99	0,98	0,98
III	0,99	0,97	0,98
aVR	0,98	0,95	0,96
aVL	0,98	0,94	0,98
aVF	0,99	0,97	0,94
V1	0,99	0,95	0,96
V2	0,98	0,98	0,94
V3	0,94	0,97	0,97
V4	0,97	0,99	0,96
V5	0,98	0,99	0,94
V6	0,98	0,98	0,96

Table 1: Correlation coefficients for parameters of CardioSecur and Philips over 41 patients.

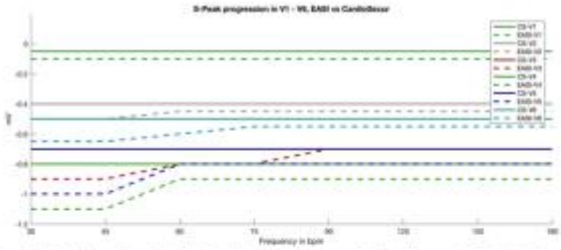

Figure 3: Absolute S-peak amplituds for CardioSecur and Philips over different frequencies for V1 to V6.

Conclusion

This study has shown that the clinical information in the CardioSecur device is identical to the information of ECGs of the Philips M2601B device. A small difference in peak heights of the raw signal arises from the different filter systems.
Morphologically, the orientation of all recorded ECGs and the R-wave progression were identical in all measured ECGs. Therefore the diagnostic capabilities of the CardioSecur device can be seen as fully comparable to those of the Philips ECG. The possible benefits of an additional 10 leads in the CardioSecur device will be the subject of future studies.

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3. The Revealing Timely ECG Change Decreases the Likelihood of Undesirable Cardiac Events-Trial (REDUCE-Trial)

Presented: European Society of Cardiology Conference, 2014.

Van Langenhove, Schwagten B.

The Revealing timely ECG changes Decreases the likelihood of Undesirable Cardiac Events-Trial (REDUCE-Trial)

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Background

- ECG technology is extremely useful in the diagnosis of a wide variety of cardiac diseases.
- Plenty of arrhythmic and ischemic conditions however are hard to diagnose and therefore treat because they don't appear during the physician's consultation.
- For cases with persistent or recurrent problems single-lead event recorders, holters or implantable devices have been developed to diagnose the underlying disease or symptoms.
- However due to their susceptibility to artefacts, the fact that they don't provide 12-lead ECG information data and a necessary invasive procedure, they may not lead to satisfying results in all patients(1).

Purpose

- To investigate whether the mobile 12-lead ECG CardioSecurTM (Personal MedSystems GmbH) is offering additional value in the management of patients with cardiac preconditions.
- CardioSecur™ is a mobile 12-lead ECG device based on the validated EASI-ECG-technology and allows for a 12-lead ECG using four electrodes only.
- Once the patient has recorded a reference ECG on the device he can perform control-readings.
- An algorithm that is based on clinical guidelines, will detect ECG changes between those two ECGs and give the patient a recommendation to act (5). E. g. in the case of minor ECG changes that patient will receive a yellow-warning and the information to make an appointment with his doctor. If major ECG changes occur the patient will receive a read warning telling him to contact his physician immediately. If no ECG changes are detected, and also if minor changes are detected, the patient is informed that he should see a physicians if symptoms pertain for longer than 20 minutes.
- ECG data can be transmitted to a database that can be accessed by the physician or medical institution.

Methods

- This is a monocentric, single-armed non-randomized trial.
- Patients were asked to undertake measurements with the device once weekly and every time they were experiencing symptoms over a maximum period of three months.
- Subsequently patients were followed up for nine months.
- At inclusion and after follow-up patients were undergoing a comprehensive diagnostic assessment consisting of standard12-lead ECG, echocardiogram and exercise-ECG.
- Inclusion criteria: 18 - 80 years of age plus CABG, PCI, AMI in the last 12 months, angina pectoris treated pharmacologically, significant rhythm disturbance for which they received either a pharmacological or electrophysiological intervention, or recurrent palpitations of unknown origin in the past. Ability to handle device, regular access to the internet, signed the informed consent form.
- The following outcomes were assessed:
- Is the device able to detect ECG-changes and give the patient a correct recommendation
- Clinical relevance.
- The local ethic's committee at the ZNA Middelheim approved the study, that was conducted in line with the guidelines for GCP and the declaration of Helsinki.

Results

- In total 51 patients were recruited between 11/2011 and 03/2012.
- Patient characteristics and main symptoms are shown in table 1.
- Patients recorded in total 1.237 ECG-readings with 2,2% of the measurements being symptom-induced and the rest being undertaken during weekly measurements.

Results

- In five patients (9,8%) the CardioSecur™ device showed its clinical relevance: It diagnosed a new or so far undiagnosed condition and let to a successful treatment. A full overview on the results of the readings, number of critical results, diagnosis and interventions performed is given in table 2.

Table 1: Patient characteristics and symptoms.

Table 2: Results of clinical value.

- Out of those five patients,
  - One patient (ID 1) was suffering from a severe ischemia (figure 1).
  - Four patients had arrhythmias with two suffering from atrial fibrillation (ID 2 & 5), one from monofocal ventricular premature beats (ID 3), with bi- and trigemina and one from AV nodal re-entry tachycardia (ID 4).

Figure 1: Patient 1 with ischemia in the inferior leads obvious T-wave inversion in leads II & III.

Reference-ECG's are in blue, control-ECG's are in green.

Figure 2: Patient 2 with paroxysmal AF in the control ECG and sinus rhythm in the reference reading albeit a first degree AV block.

- During the study period no events were reported that the device should have been able to detect.
- Patients reported a high ease of use and 80% would recommend the device to a friend or family member.

Conclusions

- We showed that CardioSecur™ system is an important tool for diagnosing cardiovascular disease and adds value in the management of patients with cardiac diseases such as rhythm disturbances and ischemic episodes. Further research is needed to validate this first study in larger patient cohorts and assess the long-term effects of this 12-lead mobile ECG.

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Declaration of Interest

This study has been supported by Personal MedSystems GmbH with an unconditional grant. G. van Langenhove owns a minority stake in the company the mentioned device.

ESC CONGRESS BARCELONA 2014 #esccongress www.escardio.org/esc2014

4. The ECGD: a derivation of the ECG from VCG leads.

J Electrocardiol. 1984 Apr; 17(2): 189-91

Dower GE

No Abstract

PMID: 6736842

5. On deriving the electrocardiogram from vectorcardiographic leads

Clin Cardiol. 1980 Apr; 3(2): 87-95

Dower GE, Machado HB, Osborne JA

Abstract
The issue of whether a traditional or scientifically based system for applying electrodes to the body for routine electrocardiography may be resolved by deriving the 12-lead ECG from the Frank XYZ signals. The result, the ECGD, is sufficiently close to the ECG for serial comparisons to be valid. Reducing data acquisition to the XYZ signals alone has several technical advantages. These have been realized with the introduction of a computer system employing the ECGD at a large general hospital. Plotting the lead vectors of the ECGD on Aitoff's projection of the sphere brings out important relationships between the leads, one to another, and to the spatial directions of the QRS and T vectors. Reversing the polarity of a VR enhances the sequential relationship between the limb leads; this is taken advantage of in an educational display generated by the computer.

6. Deriving the 12-lead electrocardiogram from four (EASI) electrodes

J Electrocardiol. 1988;21 Suppl: S182-7

Dower GE, Yakush A, Nazzal SB, Jutzy RV, Ruiz CE

Abstract

Computerized interpretation of the electrocardiogram has now advanced to computerization of the electrocardiograph, resulting in greatly increased versatility, including the capacity for adapting to a variety of lead systems rather than being tethered to the old Einthoven-Wilson-Goldberger (EWG) system. Many varieties of display beyond the 12-lead ECG are also available in software. To date, these new and interesting capabilities have scarcely been exploited. The EASI lead system uses the E, A, and I electrode positions of the Frank lead system, plus an electrode, S, positioned over the upper end of the sternum and, if necessary, ground (anywhere convenient). Its outputs form quasi-xyz signals, x'y'z', that can be approximately transformed into xyz signals by means of a matrix derived from the EASI lead vectors. The result forms a good basis for deriving the 12-lead ECG, using previously published coefficients for the Frank lead system. The match with the conventional ECG can then be improved by statistical means. The results are surprisingly good, and certainly of clinical value. Recent widespread interest in silent ischemia and its detection through Holter monitoring suggests an immediate application which has been rendered practical by the recent introduction of three-channel recorders. The EASI electrode positions give technically satisfactory Holter recordings. Very compact three-channel, multiplexed, radio telemetry equipment is now commercially available and provides another application for the EASI 12-lead ECG. (ABSTRACT TRUNCATED AT 250 WORDS)

PMID: 3216172

7. The relative accuracies of ECG precordial lead waveforms derived from EASI leads and those acquired from paramedic applied standard leads

J Electrocardiol. 2003 Jul;36(3): 179-85

Sejersten M, Pahlm O, Pettersson J, Clemmensen PM, Rautaharju F, Zhou S, Maynard C, Feldman CL, Wagner GS

Abstract

Accurate precordial electrode placement can be difficult in emergency situations leading either to loss of time or diminished accuracy. A possible solution is the quasi-orthogonal EASI lead system, with only five electrodes and easily defined landmarks to provide a derived 12-lead electrocardiogram (ECG). The purpose of this study was to test the hypothesis that precordial waveforms in EASI-derived ECGs have no greater deviation from those in gold standard ECGs, than do the precordial waveforms in paramedic acquired standard ECGs. Twenty paramedics applied the standard precordial electrodes employing the routine procedure. A certified ECG technician applied the 6 standard precordial electrodes in their correct gold standard positions, and the EASI electrodes. 12-lead ECGs were obtained from the paramedics' standard leads, and derived from the EASI leads, for comparison with the gold standard ECG. In each precordial lead recording, 6 computer-measured QRS-T waveform parameters were considered. Differences between deltaEASI-gold standard versus deltaparamedic-gold standard were calculated for every waveform in every lead resulting in 720 comparisons. EASI and paramedic results were "equally accurate" in 47%, the paramedic was more accurate in 31%, and EASI was more accurate in the remaining 22%. The differences from gold standard recording of precordial waveforms in ECGs derived from the EASI leads and those acquired via paramedic-applied standard electrodes are similar. The results suggest that the EASI lead system may provide an alternative to the standard ECG precordial leads to facilitate data acquisition and possibly save valuable time in emergency situations.

PMID: 12942479

8. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovasclar Disease in the Young: endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses.

Circulation. 2004 Oct 26; 110(17): 2721-46

Drew BJ, Califf RM, Funk M, Kaufman ES, Krucoff MW, Laks MM, Macfarlane PW, Sommargren C, Swiryn S, Van Hare GF; American Heart Association; Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young.

Abstract

The goals of electrocardiographic (ECG) monitoring in hospital settings have expanded from simple heart rate and basic rhythm determination to the diagnosis of complex arrhythmias, myocardial ischemia, and prolonged QT interval. Whereas computerized arrhythmia analysis is automatic in cardiac monitoring systems, computerized ST-segment ischemia analysis is available only in newer-generation monitors, and computerized QT-interval monitoring is currently unavailable. Even in hospitals with ST-monitoring capability, ischemia monitoring is vastly underutilized by healthcare professionals. Moreover, because no computerized analysis is available for QT monitoring, healthcare professionals must determine when it is appropriate to manually measure QT intervals (eg, when a patient is started on a potentially proarrhythmic drug). The purpose of the present review is to provide 'best practices' for hospital ECG monitoring. Randomized clinical trials in this area are almost nonexistent; therefore, expert opinions are based upon clinical experience and related research in the field of electrocardiography. This consensus document encompasses all areas of hospital cardiac monitoring in both children and adults. The emphasis is on information clinicians need to know to monitor patients safely and effectively. Recommendations are made with regard to indications, timeframes, and strategies to improve the diagnostic accuracy of cardiac arrhythmia, ischemia, and QT-interval monitoring. Currently available ECG lead systems are described, and recommendations related to staffing, training, and methods to improve quality are provided.

PMID: 15505110

DOI: 10.1161/01.CIR.0000145144.56673.59

9. Comparison of signal quality between EASI and Mason-Likar 12-lead electrocardiograms during physical activity.

Am J Crit Care. 2004 May; 13(3): 228-34

Welinder A, Sörnmo L, Field DQ, Feldman CL, Pettersson J, Wagner GS, Pahlm O.

Abstract

BACKGROUND:
Myoelectric noise and baseline wander, artifacts that appear when patients move during electrocardiographic monitoring, can cause false alarms. This problem can be addressed by using a reduced lead set and placing electrodes on the anterior part of the torso only. The Mason-Likar modification of the standard 12-lead electrocardiogram and the EASI lead system are 2 alternative systems for lead placement.

OBJECTIVES:
To test the hypothesis that the EASI lead system is less susceptible to artifacts than is the Mason-Likar modification of the standard 12-lead electrocardiogram.

METHODS:
Baseline wander and myoelectric noise amplitudes of EASI and Mason-Likar 12-lead electrocardiograms were compared. Twenty healthy volunteers participated. Both lead systems were recorded simultaneously for different types of physical activities. For each lead in each subject, baseline wander and myoelectric noise were measured for both systems, at rest and during each physical activity.
RESULTS:
The outcome for baseline wander was mixed. For myoelectric noise content, the EASI system performed better for the limb leads in the different physical activities. In the precordial leads, the differences were minimal or mixed. However, for supine-to-right turning, EASI performed worse than the Mason-Likar system.

CONCLUSIONS:
The 2 systems have similar susceptibilities to baseline wander. The EASI system is, however, less susceptible to myoelectric noise than is the Mason-Likar system. EASI performed worse than Mason-Likar for turning supine to right, because only the EASI system uses an electrode in the right-midaxillary line.

PMID: 15149057

10. Comparison of a vectorcardiographically derived 12-lead electrocardiogram with the conventional electrocardiogram during wide QRS complex tachycardia, and its potential application for continuous bedside monitoring.

Am J Cardiol. 1992 Mar 1; 69(6): 612-8

Drew BJ, Scheinman MM, Evans GT Jr.

Abstract

Previous investigators published conflicting reports comparing a vectorcardiographically derived electrocardiogram (ECGD) with the conventional 12-lead one (ECG). Prior comparisons were obtained in adults during sinus rhythm, but never in patients with wide QRS complex tachycardia. The ECGD was evaluated during baseline rhythms in patients with varying cardiac diagnoses, and the diagnostic accuracy of the 2 methods was compared during 64 episodes of wide QRS complex tachycardia in 49 patients during cardiac electrophysiologic study. All leads of the 12-lead ECGD closely resembled the conventional ECG in baseline and tachycardia tracings, except leads V3 and V4. QRS voltages were less in the ECGD, resulting in an inability to detect left ventricular hypertrophy in one third of patients with that diagnosis. There was excellent agreement between the ECGD and ECG in diagnosing prior myocardial infarction (92%), ventricular preexcitation patterns (100%), bundle branch and fascicular blocks (100%), and axis deviation. The ECGD was equally as valuable as the ECG in the diagnosis of wide QRS complex tachycardia. There was perfect agreement between the 2 lead systems in application of the morphologic criteria differentiating supraventricular tachycardia with aberration from ventricular tachycardia in leads V1, V2 and V6, and for criteria requiring axis determination and measurement of RS intervals in the precordial leads. The ECGD tracings contained less muscle artifact during body movements (e.g., after direct-current defibrillation). In conclusion, the ECGD's close correlation with the ECG, and its technical superiority and simple 5 torso-positioned electrode configuration make it worth pursuing as an option for continuous bedside monitoring.

PMID: 1536110

11. Body position effects on the ECG: implication for ischemia monitoring.

J Electrocardiol. 1997 Oct; 30(4): 285-91

Adams MG, Drew BJ.

Abstract

Rotation of the heart in relation to surface electrocardiographic (ECG) electrodes when a patient turns to one side has been reported to cause ST-segment shifts, triggering false alarms with continuous ST-segment monitoring. We prospectively analyzed ST-segment and QRS complex changes in both standard and derived ECGs in 40 subjects (18 with heart disease and 22 healthy) in supine, right- and left-lying positions. Of the 40 subjects, 6 (4 cardiac, 2 healthy) developed positional ST deviations of 1 mm or more on the standard ECG. In the derived method, five of the same six subjects showed ST-segment deviation of which most occurred in the left-lying position. Positional ST changes were most frequent for males and for cardiac patients (33%). Changes in QRS complex morphology were common on the standard (28 of 40, 70%) and less frequent on the derived ECGs (17 of 40, 43%), occurring in both healthy and cardiac subjects. QRS axis changes occurred only on the standard ECG. It was concluded that (1) right and left side-lying positions frequently induce clinically significant ECG changes; (2) positional ST-segment deviation is less frequent than previously reported and is most likely to occur in males with cardiac disease; and (3) the derived method is less prone to positional QRS changes than the standard ECG.

PMID: 9375904

12. Diagnostic accuracy of derived versus standard 12-lead electrocardiograms.

J Electrocardiol. 2000; 33 Suppl: 155-60

Horácek BM, Warren JW, Stóvícek P, Feldman CL.

Abstract

To compare the diagnostic yield of electrocardiograms (ECGs) recorded by 12 standard leads with that of 12-lead ECGs derived from 3 bipolar EASI leads, we analyzed pertinent ECG data for 290 normal subjects and 497 patients who had had a prior myocardial infarction (MI); the latter group comprised 36 patients with a non-Q MI, 282 patients with a Q-wave MI, and 179 patients with a history of ventricular tachycardia (VT). We first estimated statistically an optimal set of coefficients for deriving the 12 standard leads from EASI leads and assessed this transformation in terms of goodness of fit. To gauge the diagnostic information content of the recorded vs. derived 12-lead ECGs, we performed successively two-group diagnostic classification--based on the Cardiac Infarction Injury Score (CIIS)--separating each of the patient subgroups from the normal group; the classification was repeated for 200 sets of patients selected randomly (with replacement), and the results were plotted as mean receiver operating characteristics. We found that derived 12-lead ECGs correlated well with the recorded ones, and reproduced faithfully the diagnostic features needed for the CIIS. When the CIIS was determined from features of the recorded standard 12 leads, its mean diagnostic performance (assessed in terms of area under the receiver operating characteristics curve) was 0.9004 for detecting non-Q MIs, 0.9546 for Q-wave MIs, and 0.9919 for MIs complicated by a history of VT. When, instead, features of derived 12 leads were used to determine the CIIS, diagnostic performance remained virtually unchanged (at 0.8905, 0.9531, and 0.9906, respectively). We conclude that, in our population, EASI-derived 12-lead ECGs contain nearly the same diagnostic information as standard 12-lead ECGs.

PMID: 11265716

13. Value of a derived 12-lead ECG for detecting transient myocardial ischemia.

J Electrocardiol. 1995; 28 Suppl: 211

Drew BJ, Adams MG, Wung SF, Dower GE.

No abstract

14. Diagnosing ischemia from the bedside monitor.

Prog Cardiovasc Nurs. 1996 Winter; 11(1): 45-6

Drew BJ, Ide B

No abstract

15. Accuracy of the EASI 12-lead electrocardiogram compared to the standard 12-lead electrocardiogram for diagnosing multiple cardiac abnormalities.

J Electrocardiol. 1999; 32 Suppl: 38-47

Drew BJ, Pelter MM, Wung SF, Adams MG, Taylor C, Evans GT Jr, Foster E

Abstract

This study was performed to compare a derived 12-lead electrocardiogram (ECG) using a simple 5-electrode lead configuration (EASI 12-lead) with the standard ECG for multiple cardiac diagnoses. Accurate diagnosis of arrhythmias and ischemia often require analysis of multiple (ideally, 12) ECG leads; however, continuous 12-lead monitoring is impractical in hospital settings. EASI and standard ECGs were compared in 540 patients, 426 of whom also had continuous 12-lead ST segment monitoring with both lead methods. Independent standards relative to a correct diagnosis were used whenever possible, for example, echocardiographic data for chamber enlargement-hypertrophy, and troponin levels for acute infarction. Percent agreement between the 2 methods were: cardiac rhythm, 100%; chamber enlargement-hypertrophy, 84%-99%; right and left bundle branch block, 95% and 97%, respectively; left anterior and posterior fascicular block, 97% and 99%, respectively; prior anterior and inferior infarction, 95% and 92%, respectively. There was very little variation between the 2 lead methods in cardiac interval measurements; however, there was more variation in P, QRS, and T-wave axes. Of the 426 patients with ST monitoring, 138 patients had a total of 238 ST events (26, acute infarction; 62, angioplasty-induced ischemia; 150, spontaneous transient ischemia). There was 100% agreement between the 2 methods for acute infarction, 95% agreement for angioplasty-induced ischemia, and 89% agreement for transient ischemia. EASI and standard 12-lead ECGs are comparable for multiple cardiac diagnoses; however, serial ECG changes (eg, T-wave changes) should be assessed using one consistent 12-lead method.

PMID: 10688301

16. Comparison of standard and derived 12-lead electrocardiograms for diagnosis of coronary angioplasty-induced myocardial ischemia.

Am J Cardiol. 1997 Mar 1; 79(5): 639-44

Drew BJ, Adams MG, Pelter MM, Wung SF, Caldwell MA

Abstract

To determine whether a derived 12-lead electrocardiogram (ECG) would demonstrate typical ST-segment changes of ischemia during percutaneous transluminal coronary angioplasty (PTCA), 207 patients were monitored with continuous 12-lead ST-segment monitoring during angioplasty. Additionally, to compare the derived and standard ECGs during known periods of ischemia with PTCA balloon inflation, 151 patients were recorded with both electrocardiographic methods during the procedure. Of the 207 patients recorded with the derived ECG, 171 (83%) had typical ischemic ST-segment changes during PTCA balloon inflation. The amplitudes of these ST deviations were similar to those observed during transient myocardial ischemia observed in clinical settings (median peak ST deviation, 225 microV). There was agreement regarding presence or absence of ischemia in 150 of the 151 patients recorded with both derived and standard electrocardiographic methods (> 99% agreement). With use of the standard ECG as the "gold standard" for ischemia diagnosis, there were no false-positive results and only 1 false-negative result with the derived ECG. Furthermore, there was nearly perfect agreement between the two 12-lead methods in terms of anterior versus inferior wall patterns of ischemia. Future studies are required to determine whether continuous monitoring with a derived ECG would improve diagnosis and lead to better patient outcomes.

PMID: 9068524

17. Comparability of 12-lead ECGs derived from EASI leads with standard 12-lead ECGs in the classification of acute myocardial ischemia and old myocardial infarction.

J Electrocardiol. 2002; 35 Suppl: 35-9

Rautaharju PM, Zhous SH, Hancock EW, Horàcek BM, Feild DQ, Lindauer JM, Wagner GS, Pahlm O, Feldman CL.

Abstract

We compared 12-lead electrocardiograms (ECGs) derived with an improved transformation matrix from EASI leads and standard 12-lead ECGs in the detection of acute myocardial ischemia and old infarction (MI). For the ischemia test, we used ECGs of 40 patients recorded prior to and at peak inflation during percutaneous transluminal coronary angioplasty, and for old MI we used test ECGs of 382 non-MI subjects and of 472 patients with prior MI documented by enzyme findings. Two experienced ECG readers served as separate, independent standards for lead-set comparisons, and the Philips ECG analysis program also classified the ECGs. The results showed no significant differences between the two lead sets in the detection of acute inflation-induced ischemia or of old MI according to coding by the electrocardiographers or the computer program. No significant differences were found between the electrocardiographers and the lead sets for acute ischemia. Classification differences between the electrocardiographers were larger than those between the lead sets for acute and old MI and were significant for the latter (P <.001). A more detailed comparison of the lead sets suggested a possible need for modified old-MI criteria and optimization of ST classification thresholds for acute ischemic injury, specific for the EASI 12-lead ECG. We conclude that the EASI-derived 12-lead ECG deserves serious consideration as an alternative to the standard 12-lead ECG in emergency situations and for monitoring in acute-care setting.

DOI: 10.1054/jelc.2002.37152

18. Derived 12-lead ECG. Comparison with the standard ECG during myociardial ischemia and its potential application for continuous ST-segment monitoring

J Electrocardiol. 1994; 27 Suppl: 249-55

Drew BJ, Koops RR, Adams MG, Dower GE

No Abstract

19. Comparison of a new reduced lead set ECG with the standard ECG for diagnosing cardiac arrhythmias and myocardial ischemia.

J Electrocardiol. 2002; 35 Suppl: 13-21

Drew BJ, Pelter MM, Brodnick DE, Yadav AV, Dempel D, Adams MG

Abstract

In a few patients, 12-lead electrocardiograms (ECGs) derived from reduced-lead-set configurations do not match the standard ECG. Constructing an ECG from a reduced number of standard leads should minimize this problem because some of the resultant 12 leads would always include "true" standard leads. The purpose of this study was to compare the ability of a new reduced-lead-set 12-lead ECG ("interpolated" ECG) with the standard ECG to diagnose cardiac arrhythmias and acute myocardial ischemia. The interpolated ECG uses six standard electrode sites (limb leads plus V(1) and V(5)), from which the remaining four precordial leads (V(2), V(3), V(4), and V(6)) are constructed. Standard and interpolated ECGs were compared using data from 2 prospective clinical trials involving 649 patients evaluated for 1) chest pain in the emergency department (ischemia group, n = 509) or 2) tachycardias in the cardiac electrophysiology laboratory (arrhythmia group, n = 140). Diagnoses were identical between standard and interpolated ECGs for bundle branch and fascicular blocks, left atrial enlargement, right ventricular hypertrophy, prior inferior myocardial infarction (MI), and the distinction of ventricular tachycardia from supraventricular tachycardia with aberrant conduction. There was 99% agreement for prior anterior MI (kappa, .935, P =.000). The percent agreement for acute myocardial ischemia on the initial ECG recorded in chest-pain patients in the emergency department was 99.2% (kappa, .978, P =.000). Of the 120 patients who had ST events with continuous standard 12-lead ECG monitoring, 116 (97%) also had criteria for transient ischemia with the interpolated ECG (ie, DeltaST >or= 100 microV in >or=1 lead(s) lasting >or=1 minute(s). The interpolated 12-lead ECG is comparable to the standard ECG for diagnosing multiple cardiac abnormalities, including wide-QRS-complex tachycardias and acute myocardial ischemia. The advantages of this ECG method are that the standard electrode sites are familiar to clinicians and that eight of the 12 leads are "true" standard leads. Hence, QRS-axis and morphology criteria for diagnosing wide-QRS-complex tachycardia and bundle branch and fascicular blocks are preserved.

PMID: 12539095

DOI: 10.1054/jelc.2002.37150

20. ESC Guidelines for the managemtn of acute myocardial infarction in patients presenting with ST-segment elevation

Ph. Gabriel Steg, Stefan K. James, Dan Atar, Luigi P. Badano, Carina Blomstrom Lundqvist, Michael A. Borger, Carlo Di Mario, Kenneth Dickstein, Gregory Ducrocq, Francisco Fernandez-Aviles, Anthony H. Gershlick, Pantaleo Giannuzzi, SIgrun Halvorsen, Kurt Huber, Peter Juni, Adnan Katrati, Juhani Knuuti, Mattie J. Lenzen, Kenneth W. Mahaffey, Marco Valgimigli, Arnoud van't Hof, Petr Widimsky, Doron Zahger, Jeroen J. Bax, Helmut Baumgartner, Claudio Ceconi, Veronica Dean, Christi Deaton, Robert Fagard, Christian Funck-Brentano, David Hasdai, Arno Hoes, Paulus Kirchhof, Juhani Knuuti, Philippe Kolh, Theresa McDonagh, Cyril Moulin, Bogdan A. Popescu, Zeljko Reiner, Udo Sechtem, Per Anton SIrnes, Michal Tendera, Adam Torbicki, Alec Vahanian, Stephan windecker, David Hasdai, Felicity Astin, Karin Åström-Olsson, Andrzej Budaj, Peter Clemmensen, Jean-Philippe Collet, Keith A. Fox, Ahmet Fuat, Olivija Gustiene, Christian W. Hamm, Petr Kala, Patrizio Lancellotti, Aldo Pietro Maggioni, Béla Merkely, Franz-Josef Neumann, Massimo F. Piepoli, Frans Van de Werf, Freek Verheugt, Lars Wallentin

First published online: 24 August 2012

21. Comparison of waveforms in conventional 12-lead ECGs and those derived from EASI leads in children.

J Electrocardiol. 2003 Jan; 36(1): 25-31

Pahlm O, Pettersson J, Thulin A, Feldman CL, Field DQ, Wagner GS

Abstract

To investigate the possibility of simplifying electrocardiogram (ECG) recording in children, we compared waveforms in conventional 12-lead ECGs to those derived from EASI leads in 221 children of various ages. The conventional 12-lead ECGs and the ECGs using EASI electrode positions were collected simultaneously. We developed and determined the value of age-specific transformation coefficients for use in deriving 12-lead ECGs from the signals recorded at the EASI sites. We compared the results of using age-specific coefficients to the results of using adult coefficients and studied the "goodness-of-fit" between the conventional and the derived 12-lead ECGs. The age-specific coefficients performed slightly better than the adult coefficients, and good agreement was usually attained between the conventional 12-lead ECG and the EASI-derived 12-lead ECG. Our conclusion is that EASI leads in children have the same high levels of "goodness-of-fit" to replicate conventional 12-lead ECG waveforms, as reported earlier in adults.

PMID: 12607193

DOI: 10.1054/jelc.2003.50006

22. The importance of derived 12-lead electrocardiography in the interpretation of arrhythmias detected by Holter recording.

Am Heart J. 1992 Oct; 124(4): 905-11

Denes P

Abstract

Holter monitoring has been used extensively for the detection, diagnosis, and evaluation of therapy for cardiac arrhythmias. The availability of three-channel monitors allows for the recording of vectorcardiographic leads X, Y, and Z. One method, which was recently described by Dower et al., (J Electrocardiol 1988;21:5182-7), uses modified vectorcardiographic leads and allows for the acquisition of a derived 12-lead ECG of selected rhythm strips during the recording. In the present study, we evaluated the usefulness of the derived 12-lead ECG in the detection of P-wave and ST-segment shifts, assessment of QRST changes, and distinction between ventricular ectopic and aberrant supraventricular complexes. Our preliminary findings indicate that careful analysis of the derived 12-lead ECG provides additional information for a more accurate diagnosis of arrhythmias that are detected by the Holter monitor. The clinical importance and cost-effectiveness of the derived 12-lead ECG needs further evaluation.

PMID: 1382387

23. Simultaneous comparison of 3 derived 12-lead electrocardiograms with standard electrocardiogram at rest and during percutaneous coronary occlusion.

J Electrocardiol. 2008 May-Jun; 41(3): 230-7.

Nelwan SP, Kors JA, Crater SW, Meij SH, van Dam TB, SImoons ML, Krucoff MW

Abstract

AIM:
The aim of the study was to simultaneously test the EASI lead system and two other derived ECG methods against the standard 12-lead ECG during percutaneous coronary intervention (PCI).

METHODS:
During 44 percutaneous coronary interventions, a simultaneously recorded 12-lead and EASI ECG were marked at the start of the PCI (baseline) and at known ischemia caused by balloon inflation (peak). ST deviations were measured 60 ms after the J point at baseline and peak in all leads and were summated (SUMST) to assess overall changes. For regional changes, the lead with the highest ST deviation (PEAKST) was marked. For each patient, derived 12-lead ECGs were computed from the EASI leads and a lead subset using patient-specific coefficients (PS) and coefficients based on a patient population (GEN). Absolute differences were computed between each derived and routine ECG for SUMST and PEAKST.

RESULTS:
SUMST was at baseline 567 microV (range: 150-1707) and increased at peak to 871 microV (range: 350-2101). SUMST difference at peak was for EASI: 163 microV (CI: 90-236, P <.001), GEN: 46 microV (CI: 2-91, P = .40), and PS: 16 microV (CI: 3-30, P = .15). PEAKST difference at peak was for EASI: 49 microV (CI: 19-220, P = .02), GEN: 48 microV (CI: -43-154, P = .26), and PS: 20 microV (CI: -51-32, P = .65).

CONCLUSION:
Simultaneous direct comparison of three derived ECG methods shows overall and regional differences in accuracy across PS, GEN, and EASI. Median SUMST and PEAKST differences for PS are lower than for GEN and EASI, and show a more accurate reconstruction.

PMID: 18433614

DOI: 10.1016/j.jelectrocard.2008.01.011

24. ST Segment Monitoring with a Derived 12-lead Electrocardiogram is superior to routine cardiac care unit monitoring.

Am J Crit Care. 1996 May; 5(3):198-206.

Drew BJ, Adam MG, Pelter MM, Wung SF.

Background
Prior studies have shown that a derived 12-lead electrocardiogram with a simple electrode configuration is comparable with the standard electrocardiogram for arrhythmia analysis.

Methods
A prospective, comparative, within subjects design was used to compare the value of the derived 12-lead electrocardiogram with that of routine monitoring of leads V1 and II for detection of transient myocardial ischemia in 250 patients treated for unstable angina or myocardial infarction.

Results
During 11,532 hours of derived 12-lead ST segment monitoring, 55 (22%) of 250 patients had 176 episodes of ischemia. Of the 55 patients with ischemia, 75% reported no chest pain and 64% had no ischemic ST changes with routine monitoring leads. All five patients who developed angiographically confirmed abrupt reocclusion after percutaneous transluminal coronary angioplasty had ischemic ST changes with the derived electrocardiogram (sensitivity, 100%), compared with only two patients with routine monitoring (sensitivity, 40%). Serious complications occurred in 17% of angina patients with ischemic events compared to 3% of those without ischemia. Length of stay in the cardiac care unit was twice as long in angina patients who had ischemic events. In patients with acute myocardial infarction, ischemic events were not associated with a more complicated hospital course; however, length of stay in the cardiac care unit was longer in patients with recurrent ischemia.

Conclusions
The findings show that derived 12-lead ST monitoring is superior to routine monitoring of leads V1 and II for detecting transient myocardial ischemia. ST monitoring of the derived 12-lead electrocardiogram may identify high-risk patients with unstable angina and provide prognostic information that would not be otherwise available from the usual clinical measures.

PMID: 8722923

25. Comparison of the standard ECG with the EASIcardiogram for ischemia detection during exercise monitoring.

Computers in Cardiology 1997.

Feldman CL, MacCallum G, Hartley LH

Abstract

The methodology for constructing the 12 lead ECG from Dower's EASI lead system-5 electrodes, all located at easy landmarks over bony areas of the thorax-has been recently updated with newly optimized coefficients. To test the ability of the updated EASIcardiogram to detect ischemia, 54 patients undergoing symptom limited, Bruce protocol exercise testing were studied with simultaneous standard 10 electrodes and EASI 5 electrode lead systems. Concordance between the two systems was 83%. In 34 patients with recent coronary angiograms sensitivity and specificity of the EASIcardiogram for detection of coronary disease were at least as good as that of the standard EGG. It is concluded that ST segment depression detected by the EASIcardiogram is very similar to that which is detected by the standard ECG and that the EASIcardiogram appears to have sensitivity and specificity at least equal to that of the standard ECG for detection of myocardial ischemia.

Doi: 10.1109/CIC.1997.647903