The Spatial Vectorcardiogram Obtained by Use of a Trihedron and Its Scalar Comparisons

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The spatial vectorcardiogram is supposed to represent the path of the cardiac vector viewed from a rather large distance. With this in mind, the authors propose a vectorcardiographic method based on a trirectangular trihedron. Comparisons are made between calculated scalar leads derived from the spatial vectorcardiogram, and real scalar leads recorded from the subject. In case of concordance the hypothesis of a single instantaneous cardiac vector within an homogeneous conducting medium is verified. This was found to hold for most circumstances. However, for those instances in which discrepancies arose another hypothesis is advanced.

Spatial vectorcardiography intends to represent the variations of the instantaneous cardiac vector as a function of time. This generally accepted definition implies the idea of an instantaneous resultant of all the elementary electrical sources of the heart. In principle such a resultant can be conceived or represented only if all electrical sources are viewed from a rather great distance, bearing in mind the volume occupied by the generator organ, the heart. Admitting that the vectorcardiogram which expresses the successive resultants can be obtained, the actual problem consists in knowing to what extent the successive fields corresponding to these resultants agree with the real electrical fields of the heart, as they are accessible on the human body in the form of multiple scalar tracings recorded at various points on the surface or even from the interior of the human body.

In the attempt to resolve this problem, we started with the spatial vectorcardiographic tracing taken at a given distance from the heart and used a method of leading based on a trirectangular trihedron. The latter is different from the trihedron previously proposed by Schellong. The actual research consisted in comparing the scalar electrocardiograms derived from this vectorcardiogram and the real scalar electrocardiograms.

This study necessitates certain remarks concerning the conducting medium of the body. Several opinions have been voiced on this subject of which two have claimed our attention, that of Wilson, on the one hand, and that of Burger on the other.

Wilson, like Einthoven, accepted the simplified representation of instantaneous electrical cardiac sources in the form of a single dipole placed centrally or eccentrically within a sphere of homogeneous conductibility. He considered that this simplification took into account a certain number of observed facts with sufficient accuracy to explain the principles governing the distribution of potentials within the body. Nonetheless, Wilson, having also considered the fact that these sources occupy an important volume, has been led recently to resort to the physical expression of Poisson’s integral. The latter gives a better approximation to the reality than does the first concept which considered only a single dipole. The two conceptions are not, however, in opposition to one another.

More recently Burger, considering the irregularity and heterogeneity of the human body as a conductor, tried to avoid comparisons with an homogeneous medium, spherical or not spherical. The composition and form of the body’s conductors being unknown, Burger tried to imitate the actual conditions by using a mannequin. Inside this “phantom” he placed an artificial dipole in several places within the region occupied by the heart. In doing this, he
SPATIAL VECTORCARDIOGRAM OBTAINED BY A TRIHEDRON

Likewise considered the hypothesis of an instantaneous electrical resultant. This process permitted him to demonstrate experimentally the distribution of the potentials, that is, the electrical field produced at all points of the phantom, and at the same time led him to a logical and individual method of recording a human vectorcardiogram.12

METHOD

In our research, we have chosen the most accessible hypothesis for a comparative method, that which supposes an homogeneous body medium containing at every instant a single resultant dipole or vector.

Fig. 1. Bipolar vectorgraphic leads defining a right trihedral angle, as used by the authors. The four lead points $n o p q$ are equidistant from the center of the heart, represented here by a cross. In the perspective view (to the right) the points $n o p$, pictured as empty squares, lie in the plane of the back. In the center, section of the trunk at level $n$ and $o$; $d =$ transverse diameter of the body at the level $o$. The authors.

Fig. 2. Normal subject, 22 years old. Above: frontal and transverse vectorcardiogram (accurate copies of original tracings). The numbers corresponding to points along the vectorcardiogram indicate the time in hundredths of a second. The T curve is drawn in more darkly than QRS. The P curve is not represented. The scale of amplification of the vectorgraphic curves is indicated on perpendicular axes of the vectorcardiograph figures (0.2 millivolt). The broken lines represent the actual unipolar axes $V_R$, $V_L$, $V_F$ and $V_1$ to $V_6$ (slanted numbers) made from precise measurements on the subject. (See corresponding scales in centimeters.) The dotted lines connecting points 1 to 6 (that is, $V_1$ to $V_6$) reproduce part of the transverse perimeter of the thorax, obtained by molds, at the level of the center of the ventricular mass. Below: Table of comparisons between real electrocardiogram, to the left in each of three columns, and the electrocardiogram derived from the vectorcardiogram, to the right in each of three columns. Time = 0.02 second.
We have also considered the hypothesis of several components, that is, synchronous dipoles which cannot be replaced by a single dipole in certain definite cases. The conditions of a sphere or infinite volume have permitted recourse to simple physical formulas in both circumstances. In the case of the hypothesis of a single instantaneous resultant, sometimes a point with a fixed origin and common to successive vectors was considered; at other times, a point of origin moving as a function of the time.

The comparative method mentioned above is based on the electrical moments of the successive resultant dipoles expressed by the vectors of the spatial vectorcardiogram. From these vectors the presumed potentials are calculated for any given point on the surface or inside the body. The results expressed in the form of scalar quantities varying with the time are compared with the true electrocardiograms registered at these same points. These corrections have been applied in this present work.

Under these conditions the vectorcardiogram permits the calculations of the electrical moments of successive cardiac dipoles, the various distances being accessible.

Starting with a spatial vectorcardiogram made according to this principle, it is easy to deduce all scalar leads, unipolar or bipolar. Three factors must be taken into account: (1) the cardiac vector in

![Diagram](http://circ.ahajournals.org/)

Fig. 3. Normal subject, 29 years old. Right upper: transverse vectorcardiogram. Right lower: thoracic perimeter with unipolar lead points; interior, anatomic contour of the ventricular mass as delimited by radiologic control. Inside the heart, points A, B, C, D, E, F, G designate the successive positions of the point of origin of the vectors during QRS-T. These letters correspond to precise instants of the vectorcardiogram shown separately to the left of the figure. The broken lines used here indicate the vector radii. For other notations and markings, see figure 2.
space, (2) the axis of the chosen lead, and (3) the
distance to the center of the heart.
In comparing the calculated tracing with the
real tracing taken at a given point, account is taken
of the timing and the voltage of the two scalar trac-
ings, real and calculated. The comparisons so made
consider, in the main, points situated in the frontal
plane of the body and in a transverse plane passing
through the center of the heart. Those points con-
cerning the frontal plane are \( V_R, V_L, V_F \), and consequently the standard leads. For the case of the trans-
verse plane, we have transposed the positions of the
points \( V_1 \) to \( V_5 \) as well as those from \( V_{3R} \) to \( V_{8R} \) and
the medial posterior line (MPL) to the same trans-verse plane passing through the fifth or at times the
sixth intercostal, parasternal space. The level (fifth
or sixth space) is selected in each particular case ac-
cording to the localization of the anatomic center of
gravity of the ventricles as determined by radiologic
methods, the subject lying in the supine position.
This alignment of the precordial points is not ex-
actly in conformity with standardized conventions
which place the points of application \( V_1 \) to \( V_5 \) along
a broken line. The nonobservance of these conven-
tions avoids additional work which in the long run
would render little profit to the proposed research.
The few comparisons which are made for leads
from the interior of the body are drawn from a series
of unipolar axes which are not necessarily placed in
a single plane. Therefore the derived scalar leads
were drawn from plastic models of the spatial vector-
cardiograms.
In all these circumstances the location of all lead
points of the actual electrocardiograms has been
determined as accurately as possible. Individual
body measurements and thoracic molds\(^5,6\) were
utilized and we were also guided by radiographs
taken in two orthogonal planes. Our vectorcardio-
graphic recorder is a three channel amplifier with
double beam cathode ray tube.

**Material and Results**

The spatial vectorcardiograms of 102 sub-
jects have been compared with the scalar elec-
trocardiograms according to the principles in-
dicated above. The hypothesis of a resultant
vector whose point of origin is either fixed or
mobile has been verified for 94 subjects: 31
normal subjects, nine patients with left ventric-
ular hypertrophy, two with right ventricular
hypertrophy, seven with left and eight with
right bundle branch block, 17 with myocardial
infarction, six with the Wolff-Parkinson-White
syndrome, 13 with congenital anomalies, and
one with a Lutembacher syndrome. The hy-
pothesis of a resultant vector has not been found
adequate for eight subjects: four patients with
mitral stenosis, one with right ventricular hy-
pertrophy, one with cor triloculare, one with
the Lutembacher syndrome and one with myo-
cardial infarction. Six representative cases are
discussed in detail in the next paragraphs.

(1) *Example of a Case in Which the Hypothesis
of a Fixed Point of Origin of the Resultant
Vectors is Verified*

The case is that of a normal male, 22 years old,
of a pyknic build. The point of origin common to
the vectors during QRS-T is placed at the anatomic
center of gravity of the ventricles (the center was
located radiographically). Figure 2 shows the frontal
and horizontal vectorcardiogram and the real uni-
polar axes of leads \( V_R, V_L, V_F \), as well as \( V_1 \) to \( V_5 \).
Considering the unequal distances of \( V_R, V_L \) and \( V_F \)
from the cardiac center, the values for the standard
leads I, II and III are obtained by arithmetic sub-
traction from the unipolar values, i.e. \( V_1 - V_R, V_F - V_R, V_F - V_L \) and not by simple projections
on the lines of the bipolar leads \( I_R, R_F \) and \( L_F \). The
results of the comparison of these 12 leads are shown by the tracings placed in the lower part of the figure. The approximation that was obtained has been judged good enough to suggest that the proposed hypothesis is verified.

points of origin at different instants of QRS-T. Thus, knowing the length of the thoracic diameter and the potentials existing at each of the two extremities, we have calculated the position of the point of origin of the cardiac vector on this axis. The letters A, B, C, and D are used to mark the centers of the points of origin.

(2) Example of a Case in Which the Hypothesis of a Continuous Displacement of the Point of Origin of Successive Vectors during QRS-T is Verified

The case serving for this illustration is again that of a normal male, aged 29, 180 cm. tall, of an athletic build. Figure 3 shows his transverse vectorcardiogram which alone is discussed. The comparisons of 13 unipolar leads taken at the periphery of a transverse plane at the level of the fifth intercostal space have served for the calculated determination of the

...G indicate the centers so determined. Each of them is valid for only a part of the vectors. It is shown that the displacement follows a certain path always within the anatomic limits of the heart. Note that A and B are located in the region of the septum; C and D are in the zone of the left ventricle; E, F, and G (T wave) are on a straight line, confirming what we had found recently to be the case in other normal subjects. Figure 4 gives the collected comparisons between the real scalar leads and scalar leads constructed on this principle. The conformity of the tracings with respect to chronol-
ogy and voltage has been deemed sufficient to claim that the hypothesis of a displacement of the point of origin is verified.

(3) Example of a Case of Right Bundle Branch Block in Which the Hypothesis of Three Principal, Successive Points of Origin during QRS-T is Verified

The successive stimulation of left and right territories brought about by a bundle branch block is a favorable condition for the study of two distinct points of origin of the cardiac vectors. As in the preceding case, the location of the points of origin has been worked out by calculation and comparison of the opposite leads all around the thorax on a transverse plane passing through the fifth intercostal space. The case chosen here is that of a 50 year old woman with pulmonary sclerosis and mitral stenosis. She presented marked right ventricular hypertrophy. The horizontal vectorcardiogram taken at the level of the waist according to the technic of the spatial vectorcardiogram is reproduced in figure 5. To the left of this same figure, the vectorcardiogram is broken up into three parts: the first part, $L_0$ going from 0 second to 0.05 second and corresponding in all probability to the electrical effects of the primary excitation of territories dependent upon the intact left branch; the second, $R$, going from 0.045 second to 0.13 second translates the effects of the remaining ventricular territories situated in the right part of the heart; the third, $T$, translates the effects of collective repolarization of the ventricles. Below and to the right of the same figure the positioning of the 13 thoracic leads and the place of the three points of origin of the vectors $L$, $R$ and $T$ are represented on a reduced scale. The unipolar axes going from $L$, $R$ and $T$ to the 13 points are shown clearly so that the reader can appreciate their direction and the distances. As in the preceding case, it is to be noted that the three centers are placed within the anatomic limits of the heart and that $R$ and $L$ correspond to the anatomic localizations of the right and left ventricles, $T$ being between them.

The scalar curves derived in this manner and the real scalar curves are shown in figure 6. Again good agreement between the two series of tracings can be seen, from the aspect of chronology as well as of the configuration of the various peaks. It is interesting to note that this excellent agreement is manifested equally for so-called semidirect leads such as $V_1$ and $V_5$, and for more distant leads, for instance $V_{GR}$ and $V_{SR}$. A partial discordance exists between real and calculated curves for $V_3$ and $V_4$. As far as the general amplitude or voltage of the tracings is concerned, a good correspondence can be shown for the majority of the curves; the greatest difference to be observed is in $V_{BR}$.

In spite of these minor differences it is surprising to see the startling similarity of the two series of electrocardiograms. This fact should be emphasized in this example where the slenderness of the thorax and the great enlargement of the heart created conditions which resulted in the electrodes being very near the heart. For this reason we feel it can be said that the proposed hypothesis is upheld.

(4) Example of a Case Where, for a Part of the Period of Depolarization Only, the Hypothesis of a Single Electrical Resultant Cannot be Upheld

The case which serves to illustrate this example is characterized by conditions which are well known in scalar electrocardiography. These conditions are mitral stenosis accompanied by marked right ventricular hypertrophy. The patient was a 17 year old male. At first glance it can be seen that the opposite unipolar leads do not give mirror images. The study of this example has been done by a slightly different method than that applied heretofore, and consists in comparing four unipolar vectorcardiograms according to the four quadrants of a transverse plane at the level of the heart (fig. 7).
At the center of the four figures a fifth one is to be noted which is the horizontal vectorcardiogram taken at a given distance in the way described above for the registration of the spatial vectorcardiogram. The disagreement between the five figures seems to prove the nonvalidity of the hypothesis of a single resultant. Here the chronologic matching of the five vectorcardiograms calls for an immediate comment. The vectors 3, 4, 5 and 6 are in fact not comparable either in direction or in amplitude. On the other hand, the vectors 1, 2, 7, 8 and 9, that is to say the beginning and end of the rapid ventricular complex, as well as the whole of the T wave, are in agreement to a degree of approximation which meets with the conditions invoked in the first paragraph (fig. 2). The data confirm the validity of the hypothesis of an instantaneous resultant vector with a fixed point of origin for the greater
part of QRS-T. But the complete discrepancy for a part of the vectors of QRS requires the following consideration: the hypothesis of an instantaneous

(5) Example in Which Comparison of Unipolar Electrocardiograms Recorded inside the Trunk and Calculated Electrocardiograms Verifies the Hypothesis of a Fixed Point of Origin for the Vectors during QRS-T.

The internal leads to be considered concern esophageal points and intravascular points in the venae cavae and the right atrium. The leads have been recorded by means of esophageal electrodes and venous catheterization in several cases of which two are given below as examples.

The first (fig. 8) concerns esophageal leads in a subject 58 years of age who had had a posterior infarction of the myocardium three years before. The calculated scalar tracings for comparison have been derived from a plastic model of the spatial vectorcardiogram because of the evident fact that points 1, 2, 3 and 4 define, with the center of the ventricles, unipolar axes that are not contained within one single plane.

The calculated scalar tracings are derived from vector projections on four axes of the same spatial direction as the real unipolar axes in the body. This difficult determination has been carried out by use of successive frontal and profile radioscopic determinations made for each new position of the esophageal electrode. The real tracings in the same positions are matched with the derived curves without accounting for the factor of absolute amplitude imposed by the different distances to the center of the heart. Therefore, the comparison is applicable only to the chronology and the configuration of the tracings. The agreement of the two series is satisfactory even though this case concerns a posterior myocardial infarction and esophageal tracings. Consequently we venture to claim that with this patient the hypothesis of an instantaneous resultant and of a fixed point of origin for all of the vectors is rather well maintained.

The second example (fig. 8) has been drawn from intravascular leads obtained by venous catheterization in a subject 55 years old suffering from a chronic pulmonary disease plus first degree right bundle branch block and right ventricular hypertrophy. The leads considered are five in number and range from the superior vena cava to the inferior vena cava with leads from the intervening right atrium. These five points can be assumed to lie practically in a frontal plane of the body which passes through the center of the heart. That in turn permits us to work out the derived electrocardiograms from the frontal vectorcardiogram made according to the method used for the spatial vectorcardiogram.

The respective orientation of the unipolar axes was established by orthodiagraphy which was done at the time of the venous catheterization.

The results of the comparisons are very satisfactory, as shown by the tracings in figure 8. It

Fig. 8. Two examples of scalar comparisons concerning intrathoracic unipolar electrocardiogram. On the left, posterior myocardial infarction. Standard leads I, II, III, orthodiagram with esophagus and esophageal leads. Tracings 1, 2, 3, 4 correspond to the different sites of the esophageal electrode as indicated on the orthodiagram. On the right, chronic pulmonary disease with right ventricular hypertrophy and right bundle branch block. Standard leads I, II, III, orthodiagram with frontal vectorcardiogram and intravascular leads. Tracings A, B, ..., E correspond to the different sites of tip of intravascular catheter as indicated on the orthodiagram. The broken lines indicate the five unipolar axes emanating from the center of the ventricular mass; here this center is assumed to correspond to point of origin of the vectorcardiogram. In both columns of tracings the real electrocardiograms are labeled and placed on the left side; the corresponding calculated electrocardiograms are to the right.

resultant cannot be accepted, in spite of the effort made to find one or several adequate points of origin. An attempt to explain this phenomenon is given in the course of the discussion.
may be said, therefore, that the hypothesis of an instantaneous resultant of successive vectors of QRS-T and of a point of origin common to all of them is upheld by this example. The fact that unipolar tracings are recorded from the proximity of the heart and even from the interior of the atrial cavity does not impair the validity of the chosen hypothesis.

**DISCUSSION**

The majority of comparisons of real and derived electrocardiograms calculated from spatial vectorcardiograms show remarkable agreement in normal subjects as well as in patients with cardiac disease. Faced with these facts it is possible to accept in a general fashion the comparison which relates the successive electrical fields created by the heart to a series of electrical fields created by successive resultant dipoles placed in a homogeneous conducting medium. The fact that examples are shown in which the position of the dipole varies with the time does not weaken this last statement.

Thus, to a great extent, the hypothesis stated at the beginning of this paper is upheld. It has been shown that exploration close to the heart, on the precordium or inside the thorax most often does not contradict the same conception. The hypothesis maintains its validity in extreme circumstances which, a priori, seemed incompatible. These conclusions are obviously a matter of personal evaluation. Since the complete data are given for every example, our results can be readily re-examined by the reader and the adopted criteria submitted to discussion. The requirements adopted to define concordance are not limited just to analogies but rest upon strict analysis of the chronology and the values of the potentials at every point. In order to arrive at this result the greatest amount of attention has been paid to all the technical details, which are so important in this type of work.

It has been shown that the vectorcardiographic method of the trirectangular trihedron gives remarkably constant results. This method, amply expounded and discussed by us and others,\(^2\) \(^6\) \(^11\) offers a certain number of real and theoretic advantages but presents at the same time certain difficulties in its application. For example, it is not always possible to guarantee that the four points are equidistant from the anatomic cardiac center. Certain subjects, because of their anatomic shape, make the measurements particularly difficult. Lastly, even admitting a correct geometric application, the inequalities of the body's conducting medium is a matter of fact and constitutes always an unpredictable factor of minor discrepancy.

Each method presents some errors and unknowns. Undoubtedly, vectorcardiographic processes, using one or several leads close to the heart, easily bring about distortions of the spatial vectorcardiogram for which several reasons are brought out clearly in the exposition of the data reported in this paper. The use of the limbs in vectorcardiographic leads, as in Wilson's tetrahedron\(^15\) for example, necessitates again reservations in some respects: the inequality of the distance from the heart to the shoulders\(^16\); the lack of precision of the points of application occasioned by ill-defined points of junction of the limbs with the torso.

Having made these reservations, it is not possible for us to evaluate the relative merits of the different vectorcardiographic methods employed at the present time when used for comparative studies like the present one, since until now this has been done only on the basis of the trihedron. Recently, Milnor and co-workers\(^17\) have stated that the differences are sometimes considerable.

Efforts should be made toward obtaining an "ideal" spatial vectorcardiogram; that is, toward the realization of a spatial curve which would approach as closely as possible one that could be made at a distance from the heart, beyond the limits imposed by the confines of the human body. This hope appears to be utopian for the moment, and one must be content with less satisfactory approximations which perhaps would not meet with the approval of the physicists. This goal is precisely the goal which has guided Burger\(^11\) \(^12\) in his research.

The second point of discussion concerns the discrepancies observed in the course of our comparisons. Example 4 (fig. 7) is a characteristic one. One may think that the irregularity of the conducting medium of the body and the nonspherical form of the trunk, when definite cardiac hypertrophy is present, are responsible
for such discrepancies. A careful study of the collected tracings shows that the objection is not a valid one. In fact, this example makes it appear that the hypothesis of a single instantaneous resultant vector is no longer applicable for a short period of time, that which corresponds to vectors QRS 3, 4, 5, and 6. For all the other vectors collected, the hypothesis of a single instantaneous cardiac vector can be admitted. One cannot attribute this discrepancy to the medium of the body since its form and its conductivity are the same in both circumstances.

This consideration leads us to resort to another explanation, since the hypothesis of a simple electrical field emanating from a single dipole is no longer admitted under certain conditions. It has to be replaced by the hypothesis of a complex electrical field emanating from several synchronous dipoles placed at different points. By putting this problem in a simplified theoretic form, allowing for two instantaneous component vectors, we have shown\(^8\) that under particular conditions and for certain points which are more or less close to the heart, the hypothesis of a unique resultant cannot be upheld.

At the instants displaying discrepancies, it seems as if two or several distinct cardiac territories are promotors of vectors of rather equal value and oriented in such a manner that one of these territories with respect to the exploring electrode exerts a predominant influence which masks the effects arising in all or several of the other territories. In the example discussed, a dominating influence of this type can be seen to exert itself still on points relatively removed from the heart, as \(V_{10}\) for instance.

This hypothesis, introduced to cover certain discrepancies, presents nothing unusual since it has been suggested, in fact admitted, in electrocardiography to give support to the view that precordial leads mainly record the potential variations arising in the portion of the heart near to the electrode. The example of right bundle branch block (fig. 5) clearly expresses the variable influence caused by the nearness or the distance of the various territories of the heart with respect to a given point of the body. However it is difficult to understand why this influence is not noted under all circumstances in the normal subject and also in the proved examples of cardiac hypertrophy not reported here. It is probable that the balance between opposite potentials in the heart itself, upon which Wilson\(^9\) has so strongly insisted, very often annuls electrical effects simultaneously arising from two or more territories.

The vast chapter of myocardial infarction poses several distinct vectorcardiographic problems which are not illustrated in this paper. Referring to the comparisons already worked out in such cases, it appears that injury vectors deserve consideration according to their spatial direction and anatomic location. Unilocular, plurilocular or extensive areas of infarction may lead to different hypotheses with respect to their representative vectors, fixed, mobile, single or multiple.

Our actual knowledge of the constitution of an electrical field created by a single dipole and its precise evaluation brings hope for better accuracy in the matter of localization for infarctons as well as for other focal events. One of our examples is of interest in this connection. It concerns the normal case illustrated in figure 3 where a displacement of the electrical center in the course of QRS can be inferred. For example, it can be noted that at the beginning of the QRS loop, the positions of the centers \(A\) and \(B\) correspond approximately to the region of the interventricular septum.

In conclusion, the practical application of vectocardiography is justified on condition that the principles and limits of the method are well established and its significance exactly defined. The physiopathologic clarifications that it has already contributed, when used under rigorously controlled conditions, assures it a better place than that of an empiric process.

**Summary**

1. The bases and conditions for the realization of a correct vectorcardiogram are put forth.
2. A method for recording the spatial vectorcardiogram is proposed; this method makes use of a trirectangular trihedron.

3. The hypothesis of a homogeneous conducting volume is accepted for the present research.

4. A method is proposed to compare the real electrocardiogram and the corresponding scalar electrocardiogram derived from a vectorcardiogram registered in accordance with a trihedron process. These comparisons are very satisfactory for a whole series of points on the surface and inside the trunk. The evaluation of the comparisons is based on the chronology and voltage of the tracings.

5. One hundred and two normal and pathologic cases have been used for these comparisons. Six representative cases serve as illustration for this paper: two normal subjects, one with right bundle branch block, one with mitral stenosis, one with posterior infarction and one with chronic pulmonary disease.

6. The comparisons are carried out by using the standard, unipolar limb, precordial, various thoracic, esophageal and intravascular (venae cavae and right atrium) leads.

7. According to the examples, several hypotheses are advanced and verified: (a) that of an instantaneous resultant vector with a fixed point of origin located within the heart during all of QRS-T; (b) that of an instantaneous resultant vector whose point of origin moves within the heart as a function of the time; (c) that of two or several synchronous instantaneous vectors which, under certain circumstances, exclude the idea of a single resultant.

8. Electrodes placed close to the heart furnish most often electrocardiograms which also are in agreement with the hypothesis of an instantaneous resultant, as is true for points more distant from the heart.

9. The heterogeneity of the body conducting medium plays a minor role in the observed discrepancies. The distance to the heart from every lead point determines the amplitudes of the potentials which generally agree with the physicomathematical predictions imposed by a regular electrical field.

10. The application of vectorcardiography can and must be founded upon exact physical bases, several of which are presented in this paper.

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