Unipolar Bronchial Electrocardiographic Exploration of the Heart in Man
A Preliminary Report*

By Isac Goldstein, M.D., Leon Pordy, M.D., Kenneth Chesky, M.D., Harold S. Arai, M.D., Eugene R. Snyder, M.D., and Sidney Feuerstein, M.D.

The method for exploring cardiac potentials through the bronchial tree is described in detail. It consists of obtaining unipolar bronchial leads by inserting a thin No. 4 French catheter into the secondary branches of the bronchial tree as near as possible to the surface of the heart. By this method, electrocardiograms can be obtained on the right side which resemble right auricular endocardograms. On the left side, left ventricular epicardial and cavity potentials are recorded and these are similar to direct left ventricular surface leads, left intraventricular cavity potentials and esophageal leads at the same level. No arrhythmias or serious reactions occurred during or after this procedure. Preliminary findings in 8 cases are discussed in detail.

The STANDARD limb leads have been supplemented in the past 20 years by leads with exploring electrodes placed near the heart. These supplementary leads did not include bronchial exploration because the lung was considered the poorest conductor of electricity in the body.1-3 The first successful attempt to approach close to the heart in man, reported in 1906 by Cremer,4 with an electrode in the esophagus, was reapplied by Lieberson and Liberson5 and then by Brown in 1936.6-7 After the fundamental work on left ventricular surface leads in dogs by Lewis and Rothschild8 in 1915, it became apparent that the heart should be approached in man even more directly. Einthoven himself utilized electrodes placed upon the chest. Ackerman,9 then Wolferth and Wood,10 and Wilson and his associates11a,11b firmly demonstrated the diagnostic value of the precordial leads. Following the first venous right heart catheterization in 1929 by Forssmann on himself for pressure readings,12 16 years elapsed before Lenègre and Maurice13 employed this method in man for intracavity electrocardiograms. This was followed by important contributions in this field by others.14-21 Left cavity potentials in man have been obtained by the difficult procedure of left heart catheterization by other workers.17, 22, 43 Direct epicardial electrocardiograms were taken by different investigators during thoracic exploration.23, 41 In animal experiments, extensive studies using direct endo-epicardial leads have been performed in the past 10 years.24, 26

The information obtained by venous catheterization is usually limited to the right heart and that from esophageal exploration is restricted to potentials similar to those of the left auricular and ventricular cavities and the posterior surface of the left ventricle. Since the left ventricle in man is the most important seat of coronary disease, we were interested in finding a practical method for exploring the left ventricle closer to its surface than the customary precordial leads. The method of direct cardiac surface leads of Groedel and Borchardt27 is obviously not a practical method for routine clinical investigation.

The senior author (I. G.) proposed the method for obtaining unipolar electrocardiograms by inserting an exploring electrode through the bronchial tree in order to be as near the heart as possible. The primary purpose of this procedure was to explore the left ventricular surface extensively by a clinically feasible method.

Later, extensive search of the literature revealed that Savjaloff,28a, b a Bulgarian physiologist, performed experiments in 1928 and 1929 to test the validity of the Einthoven triangle theory in the horizontal plane; he recorded bipolar leads after inserting a wire in each of the lower

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bronchi of a laryngectomized patient. Savjaloff also suggested the application of the method to patients with normal airways, by inserting the wires during bronchoscopy: he stated that this method was superior to standard electrocardiography for the study of P waves. No further work was performed along this line by others because of the accepted idea that the lung is a poor electrical conductor. The procedure of Savjaloff differs from the method of unipolar bronchial electrocardiographic exploration in that the latter provides a safe, relatively simple method for obtaining unipolar potentials similar to those from the right cavities (as in right heart catheterization), from the left heart cavities (as in esophageal leads at corresponding levels and in left heart catheterization), and finally from the surface of the left ventricle. The latter represents the most important contribution of this method.

However, at the completion of our preliminary studies, Langner and Atkins independently published their observations in 10 individuals with the method of intrabronchial electrocardiography. They reported analysis only of the contours of the QRS complexes with the intrabronchial leads and concluded that potential variation distribution in the lungs corresponded approximately and qualitatively with the potential variation distribution recorded from the surface of the body.

**METHODS**

The procedure of bronchial electrocardiographic exploration was performed in a preliminary group of 8 subjects. They were divided into two groups: (1) 3 with laryngectomies and tracheal fistulas and (2) 5 with normal airways (first to one of us—I.G.). We employed an insulated wire (in a No. 4 French ureteral catheter), 45 cm. in length, and with a rounded German silver tip. This was used as the unipolar exploring electrode (V), and the central terminal of Wilson was utilized as the reference electrode.*

The patients were examined in the fasting state and, when indicated, mild barbiturate sedation was administered (45 to 90 mg. Seconal by mouth). Electrocardiograms were taken routinely both in the recumbent and standing positions and these included the three standard limb, the three unipolar extremity, and complete circumferential unipolar (V) chest leads—a total of twenty-two leads. This procedure was followed by routine fluoroscopy of the chest.

An otolaryngologist (E. R. S. or S. F.) assisted in the insertion and positioning of the bronchial electrode. In the cases with tracheal fistulas, satisfactory local anesthesia for over one-half hour was obtained with 1 cc. of a 20 per cent cocaine hydrochloride solution sprayed through the fistula into the trachea. The exploring electrode was inserted directly and easily. In the other patients, anesthesia of the pharynx and upper larynx was obtained first by similar spray with cocaine solution and then the tracheobronchial tree was anesthetized by aerosolization of the cocaine solution. The catheter was then inserted via the normal pathway in these cases.

The patients were explored either in the standing or recumbent position. Under direct fluoroscopic control, the catheter was moved into various positions in the bronchial tree. During changes of catheter position, some patients experienced cough with expectoration of mucus which was easily controlled through aspiration. When technical conditions permitted, spot films were taken of the catheter in both posterior-anterior and oblique positions for accurate determination of the position of the catheter in relation to the heart.

The technic employed was introduction of the catheter first on the right side. This was performed easily because of the anatomic relations. Leads are taken preferably during quiet respiration. The first lead (RBa-1) is taken with the catheter tip located in an anterior secondary branch of the right lower bronchus at the level of the right leaf of the diaphragm and as near anterior to the heart as possible. Positions RBm-1 and RBp-1 are located in the middle and posterior branches of the right lower bronchus at the same level (fig. 6). By withdrawing the catheter tip cephalad to the level of the right supracardiac junction, the second position is determined (RB-2: main stem of the right lower bronchus at the level of the right supracardiac junction). The third lead on the right side is recorded at a level one inch higher (RB-3: main right bronchus at the 'evel of the great vessels).

The catheter is then inserted through the left bronchus. The fourth lead (LBa-1) is recorded with the catheter tip located in the anterior secondary branch of the left lower bronchus at the level of the left leaf of the diaphragm and as near to the cardiac apex as possible. Positions LBm-1 and LBP-1 are located in the middle and posterior branches of the left lower bronchus at the same level. The next lead on the left side (LB-2) is recorded by withdrawing the catheter tip to the level of the pulmonary conus (fig. 6). The sixth position of the tip (LB-3) is one inch higher at the level of the aorta. Similar leads should then be taken with the catheter.

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* The electrocardiographic instruments employed in this study were the single-channel direct writing Viso-cardielle (Sanborn) and, when available, the three-channel direct writing Technicon machine.
TABLE 1.—Bronchial Electrocardiographic Exploration

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Age</th>
<th>Laryngectomy</th>
<th>Routine 12 Lead ECG</th>
<th>Clinical Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. M. M. (figs. 1, 2)</td>
<td>F</td>
<td>61</td>
<td>Yes</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
<tr>
<td>2. S. D.</td>
<td>M</td>
<td>60</td>
<td>Yes</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
<tr>
<td>3. A. S.</td>
<td>M</td>
<td>54</td>
<td>Yes</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
<tr>
<td>4. I. G.</td>
<td>M</td>
<td>39</td>
<td>No</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
<tr>
<td>5. A. W.</td>
<td>M</td>
<td>46</td>
<td>No</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
<tr>
<td>6. J. P. (figs. 3–5)</td>
<td>M</td>
<td>40</td>
<td>No</td>
<td>Normal</td>
<td>Rheumatic heart disease—inactive</td>
</tr>
<tr>
<td>7. L. P.</td>
<td>F</td>
<td>20</td>
<td>No</td>
<td>Normal</td>
<td>Rheumatic heart disease—inactive</td>
</tr>
<tr>
<td>8. L. S.</td>
<td>F</td>
<td>62</td>
<td>No</td>
<td>Normal</td>
<td>Normal heart</td>
</tr>
</tbody>
</table>

Fig. 1. M.M., female, 61 years of age. Carcinoma of larynx; laryngectomy. Normal heart. Routine 12 lead electrocardiogram normal.

in the middle and posterior branches of both lower bronchi. Our experience shows that exploration may be performed with ease in the anterior, middle and posterior branches of the left lower bronchus. We intend to improve our technic by entering the right middle lobe bronchus which is near the surface of the right ventricle and also the lingula branch of the left upper lobe main bronchus which passes along the anterior surface of the left ventricle. Obviously, leads are taken in positions intermediate between those described. Occasionally tracheal leads may be of additional interest. We observed no unusual tendency toward reaction during or after the bronchial exploration. During the procedure, sinus tachycardia was usually observed, but a return to normal rate occurred shortly after completion. No arrhythmia has been observed in any case studied. This is in sharp contrast to the findings during cardiac catheterization and during routine bronchoscopy.19, 20, 21, 30–34 Michel and associates35 reported arrhythmias in 37 per cent of their patients during cardiac catheterization.

RESULTS AND DISCUSSION

From our 8 cases of bronchial electrocardiographic exploration (table 1) and the presentation of 2 typical cases (figs. 1–6), we have obtained electrocardiographic patterns corresponding to tracings demonstrated by right and left auricular catheterization, by esophageal leads at similar levels and by direct epicardial exploration of the left ventricle.

In this method, the following factors accounted for variability in potentials recorded: (1) the position and distance of the exploring bronchial electrode in relation to the heart; (2) the position of the heart in the thorax; (3) respiration; (4) possible influence of tachycardia.

When the bronchial exploring electrode was on the right side of the heart, tracings were obtained which are similar to right auricular endocardiograms. Since the electrode was outside
the heart, it was undoubtedly recording potentials from the epicardium of the right heart. The similarity of our tracings to those obtained by right auricular catheterization is in accord-

![Image](https://example.com/image)

**Fig. 2.** Same patient as illustrated in figure 1. Detailed bronchial electrocardiographic findings in table 2.

**Table 2.** Summary of Findings with Bronchial Electrocardiogram in Patient M. M.*

<table>
<thead>
<tr>
<th>Bronchial Leads</th>
<th>Position</th>
<th>Location</th>
<th>P</th>
<th>S-Tp</th>
<th>QRS</th>
<th>RS-T</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>RB p-1</td>
<td>Posterior branch of rt. lower bronchus at diaphragm</td>
<td>-</td>
<td>+</td>
<td>rSr'</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Right</td>
<td>RB-2</td>
<td>Rt. bronchus at rt. supracardiac junction</td>
<td>-</td>
<td>+</td>
<td>rSr'</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Right</td>
<td>RB-3</td>
<td>One inch higher than RB2</td>
<td>Deep-</td>
<td>+</td>
<td>rSr'</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Left</td>
<td>LBm-1</td>
<td>Middle branch of left lower bronchus at diaphragm</td>
<td>+</td>
<td>0</td>
<td>qR</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Left</td>
<td>LB-2</td>
<td>Left bronchus near pulmonary conus level</td>
<td>RS</td>
<td>0</td>
<td>QS</td>
<td>Slight +</td>
<td>-</td>
</tr>
<tr>
<td>Left</td>
<td>LB-3</td>
<td>One inch higher than LB2</td>
<td>RS</td>
<td>+</td>
<td>rS</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

* See figure 2.

We have not had the opportunity to perform simultaneous right heart catheterization and bronchial exploration. Therefore, we compared our findings with those of investigators who have done extensive work in endocardial electrocardiography.

We found three types of P wave in the right bronchial electrocardiograms. These are QSₚ, QRSₚ, and Rₚ forms identical with those observed in right auricular endocardiograms. Hence, the spatial relationship of the bronchial electrode to the sinoauricular node is the deter-

anance with the generally accepted belief that there is essentially no difference between right auricular endocardiograms and epicardiograms in man. The electrical impulse begins in the sinoauricular node and spreads through the the auricular walls in radiating waves, resulting in similar endocardial and epicardial potentials."
Fig. 3. J.P., male, 40 years of age. Rheumatic heart disease, inactive. Routine 12 lead electrocardiogram within normal limits with slight RS-T depression in leads $V_L$ and $V_3$ through $V_4$.

Fig. 4. Same case as illustrated in figure 3. Right bronchial leads with simultaneously recorded leads $V_1$ and $V_4$. RBa-1 (in anterior branch of right lower bronchus at diaphragm): RB-2 (right bronchus at right supracardiac junction) and RB-3 (one inch higher than RB-2). Note W-shaped inverted P wave; rS type of QRS complex; elevated S-Tp and RS-T segments in RB-3 representing right cavity potential. RB-2 and RB-3 are recorded both at normal and four times normal speed.
The location of the sinoauricular node is difficult to judge on fluoroscopic examination because its location varies with the position of the heart. RB-3 was the only position of the electrode on the right side in which the tip was invariably located above the sinoauricular node. In this position, the P wave was predominately inverted as in "high" right auricular endocardograms. We believe that the forms of the P wave in the right bronchial lead can be correlated with corresponding forms of the catheterization leads. Thus, QRS or RS types correspond more or less to the level of the sinus node. The R pattern is recorded when the bronchial electrode is below the sinoauricular node as in "low" right auricular endocardograms.

In our series the S-T segment was frequently above the isoelectric line* (5 cases). This positive displacement of S-T segment was also frequently observed in right auricular catheterization electrocardiograms by all investigators. Battro and Biddogia\textsuperscript{18} believe it is caused primarily by tachycardia which results in acceleration of auricular repolarization. On the other hand, Levine and his associates\textsuperscript{20} have convincingly demonstrated in their cases of right heart catheterization that tachycardia and vertical damping of the electrocardiogram are not responsible for the deviation. In their experience the probable factors involved are: (1) current of injury created by contact of the exploring electrode with the endocardium of the right auricle, or (2) a property of the position of the electrode within the right auricular cavity. Of these factors it is our belief that the position of the electrode accounts for the positive displacement of the S-T segment in bronchial leads because of the proximity of the electrode to the electrical events of the auricle. However, since the electrode is in contact with the bronchial mucosa, we cannot exclude the possibility of vagovagal reflexes producing a current of injury in the heart through reflex spasm of the coronary arteries. An interesting discussion concerning the clinical value of S-T elevation was recently reported by Kossmann and co-workers.\textsuperscript{18} Similar S-T segment elevation in animals

* The T-P interval was used as the reference line for this study.
Fig. 6. Spot x-ray films demonstrating bronchial electrode in situ on right and left sides. A. RBp-1* (in posterior branch of right lower bronchus, several inches above the diaphragm): The catheter tip is clearly seen adjacent to the right lateral cardiac border in the posterior-anterior view and to the posterior cardiac border in the right anterior oblique view. B. LB-2 (in left lower bronchus below pulmonary conus region): The catheter tip is located at the middle of the left cardiac border in the posterior-anterior view and adjacent to the posterior cardiac border in the left anterior oblique view.

has been described and analyzed by Kisch and associates.25 The ventricular complexes in the right bronchial leads simulated those obtained with the intracavity electrode at different levels of the right auricle. In most instances we recorded the rSr' or QR type which is observed in "high" and "middle" right auricular cavity positions. The ventricular rSr' and RSR' are regarded by Hecht4 as characteristic of "high auricular lead," that is, near or above the sinoauricular node. This investigator noted a consistent similarity between "high auricular lead" and lead V\textsubscript{R} and shares the opinion of others that both
of these leads reflect potentials from both ventricular cavities ("mixed potentials"). The deflection $r'$ or $R'$ is considered to represent possible terminal depolarization of the base of the right ventricle.

Occasionally, the right bronchial electrocardiogram showed an $rS$ type of ventricular complex which is usually found in "low auricular lead," that is, the pattern inscribed by a right auricular cavity electrode situated near the tricuspid orifice. This $rS$ form is regarded as being characteristic of right ventricular cavity potential by all investigators.

The $RS-T$ segment in right bronchial leads in cases with normal conduction is usually above the isoelectric line from 0.5 to 2 mm.: (a) in RB-1, 5 cases; (b) in RB-2, 3 cases; and (c) in RB-3, 2 cases. The factors which must be considered are the same as those discussed above for the $S-T_p$ segment deviation. In right ventricular catheterization leads, the most frequent cause appears to be current of injury produced by contact with the exploring electrode and the endocardium. In right bronchial leads this factor cannot be involved because the electrode is outside the heart. In our opinion, the major factor of this upward displacement is the superimposition on the $RS-T$ segment of the relatively large $T_p$ wave. A second explanation may be earlier repolarization of the ventricle produced by tachycardia with resultant $RS-T$ elevation as in intracavity leads.

The ventricular $T$ wave in right bronchial leads was in verted in all 8 cases with normal conduction, as in right-sided catheterization of normal hearts.

On the left side, the type of electrocardiogram obtained was dependent on the position of the electrode in relationship to the different areas of the left surface of the heart. The $P$ wave in LB-1 position is always upright and of relatively small amplitude. In LB-2 and in LB-3 the $P$ wave was of $RS$ or $QRS$ form in 4 cases; of $R$ form in 3 cases; and of $QS$ form in 1 case, corresponding to the level of the exploring electrode in relation to the sinoauricular node. The $P$ wave in LB-2 and LB-3 was sharp and peaked with high amplitude and in some cases the voltage of the $P$ waves at these levels is equal to that of the ventricular complex or even higher. At the LB-1 position in the few cases in which simultaneous $V_1$ and $V_4$ tracings were taken, the peak of the $P$ wave (onset of intrinsicoid auricular deflection) is delayed 0.02 second when compared with $V_1$, but simultaneous with $V_4$ (fig. 5). In LB-2 or LB-3 (at the left auricular level), the peak of the $P$ wave (onset of intrinsicoid deflection) appears from 0.03 to 0.04 second later than the $P$ wave peak in leads $V_1$ and $V_4$ (fig. 5). An esophageal lead at this level usually shows a delay of intrinsicoid auricular deflection of 0.05 to 0.07 second compared to standard leads. In the bronchial leads, the delay may be shorter because the electrode is closer to the left auricle than the esophageal electrode. The $S-T_p$ segment in the left bronchial leads is either isoelectric or slightly elevated. The factors responsible for the positive deviation of this segment are the same as those discussed for the right bronchial leads.

In LBp-1 the exploring electrode is in the left posterior basal bronchus and in LBm-1 it is in the left medial basal bronchus. In both positions the electrode is near the left leaf of the diaphragm and the ventricular complex is of the $qR$ type. In these positions, the exploring electrode is seen on fluoroscopic examination to be facing the posterior wall of the left ventricle. It thereby records epicardial potentials from this area similar to esophageal leads at this level (30 to 40 cm. from the mouth). On the other hand, when the electrode is deep in the anterior branch of the left lower bronchus and as close to the diaphragm as possible (LBa-1), fluoroscopic examination reveals the electrode to be adjacent to the lateral wall (medial aspect) of the left ventricle. Hence, it usually records potentials from the epicardial surface of this area. In 4 cases, the ventricular complex at LBa-1 was also of the $qR$ type, but of much higher amplitude than in positions LBm-1 and LBp-1. This difference in amplitude of ventricular potentials is related to the fact that in LBa-1 the electrode is either closer to the left ventricle or is in direct line with the main vectorial forces passing through the left ventricular wall.

As the electrode is brought cephalad, there is a progressive increase in the $q$ wave and pro-
gressive diminution of the R wave due to admixture of the left ventricular epicardial and left (or mixed) ventricular cavity potentials. Finally, in LB-2 and LB-3 positions, at the level of the left auricle, a typical pattern of left ventricular cavity potential (QS form) may be obtained (fig. 2, LB-2, and fig. 5, LB-3). The QR and QS forms of ventricular complex when recorded at these left bronchial positions are similar to the forms of esophageal leads at corresponding levels. In a few cases LB-3 showed a ventricular complex identical with RB-3 (corresponding symmetric position in the right bronchus). In both positions, the electrode is at the base of the heart and faces the ventricular cavities.

In 3 cases, the ventricular complexes in LB-2 and LB-3 were similar to those of LB-1; left ventricular epicardial potentials were recorded at all three positions. We believe that in such cases, despite considerable differences in positions of the electrodes, the vectorial forces traversing the left ventricular wall were of such magnitude and direction that similar complexes were recorded in all three positions. Fluoroscopically, these cases displayed horizontally placed hearts.

Another interesting finding was observed in positions LB-2 and LB-3 in 2 cases. There was a deep “QS” type of ventricular complex. Simultaneous V₁ and V₄ tracings showed that the onset of this deep “QS” in LB-2 and LB-3 began with a delay of 0.01 to 0.02 second, when compared with the onset of the QRS in leads V₁ and V₄ (fig. 5; LB-3*). It is reasonable to assume that the bronchial electrode in such instances was perpendicular to the main direction of excitation of the interventricular septum and therefore the initial portion of the QRS complex was isoelectric. This observation demonstrates the necessity for critical evaluation of any QS form of ventricular complex prior to interpretation of its origin. Only if simultaneously recorded leads demonstrate that the onset of the “QS” is simultaneous with or precedes the onset of the QRS in the reference leads, can one consider this QS to represent pure left ventricular cavity potential.

The ventricular complex in LBa-1 and LBm-1 usually resembled, but was not identi-
cal with, that of V₄, V₅, V₆ and aV₅. The type recorded in LBp-1 usually resembled that of the left posterior chest wall (V₄, V₅).

The RS-T segment in LB-1 was isoelectric in 3 cases, below the isoelectric line in 4 cases (depressed 1 to 1.5 mm.) and above the isoelectric line in one case. The RS-T alterations in LB-1 may be contributed to by at least three factors: (1) tachycardia (all our patients had an acceleration of their heart rate) producing a functional coronary insufficiency; (2) a current of injury mediated through a vagovagal reflex from the bronchial mucosa to the endocardium of the left ventricle, which would be manifested by RS-T segment elevation in intracavity leads with corresponding RS-T depression in epicardial leads such as LB-1; and (3) the closeness of the exploring electrode to the heart.

At the LB-2 level the RS-T segment was isoelectric in 5 cases and above the isoelectric line in 2 cases. The explanation of this last finding is the same as for the RS-T in the right bronchial lead. At the LB-3 level, there were 4 cases with isoelectric, one case with elevated and one with depressed RS-T segments.

The T wave of the ventricular complex in the LB-1 position was inverted in 4 cases, upright in 2, and flat or diphasic in the remaining 2 cases. Simultaneous leads V₁ and V₄ taken in 1 of the 2 cases with an upright T wave in LB-1 showed an upright T in both precordial leads. In another case, leads V₁ and V₄ recorded simultaneously showed a positive T wave, but LB-1 showed a negative T wave (fig. 5). The T-wave findings can be explained by variation of the vectorial forces of the T wave since the T vector is one of the most sensitive elements of the electrophysical forces of the heart. It may be that because the position of the bronchial electrode is such that it corresponds to the negative side of the T vector in space, a negative T wave is inscribed in the bronchial electrocardiogram with simultaneous positive T wave in V₁ and V₄. Tachycardia is another possible explanation for the inversion of the T wave in LB-1. It may change the hemodynamic factors with diminution of cardiac output, resultant reduced coronary blood flow and change in the direction of the T vector in space. We were unable to take the spatial vector-
cardiogram in all three planes and thus determine the exact position of the T loop in space. We attempted, through the practical technic employed by Grant, to find the spatial direction of the T vector. Of 4 cases studied in this manner, in only 2 could the negative T wave in bronchial leads at LB-1 be adequately explained. The differences noted between left epicardial potentials recorded in bronchial leads and in unipolar chest leads may be of diagnostic significance.

We have illustrated the findings in 2 cases with normal conduction (figs. 1-5). Since left ventricular pathology is of paramount importance and since one can explore the lateral wall of the left ventricle close to its epicardial surface through this method, selected abnormal cases will be investigated, including bundle branch block and intraventricular conduction defects. In these future explorations we shall employ this method in cases where the classic electrocardiographic findings do not coincide with the clinical diagnosis. The patterns in cases of chronic coronary insufficiency with small areas of subendocardial necrosis, previous intramural and high lateral infarction and small "window effects" will be studied. Since this new method of bronchial electrocardiography permits exploration of wide areas of the cardiac surface close to the electrophysical forces, the origin and spread of the electrical potentials of the heart will be further investigated.

**Summary and Conclusions**

1. We have corroborated that the lung is a suitable electrical conductor.

2. The technic of bronchial electrocardiography is tolerated by patients without much discomfort provided that adequate anesthesia of the bronchial tree has been obtained.

3. In our opinion, unipolar bronchial leads taken with the Wilson technic reflect potentials of the entire heart and not merely those of the myocardium underlying the exploring electrode. The pattern obtained may be influenced by the position of the electrode and its distance from the heart.

4. Leads made with the electrode in the right lower bronchus and in its secondary branches recorded patterns similar to right auricular intraventricular potentials taken in man by venous catheterization.

5. In the secondary branches of the left lower bronchus left ventricular epicardial potentials were obtained which corresponded to direct epicardial leads taken in the open chest in man. When the exploring electrode was moved cephalad in the left lower bronchus, a progressive diminution of the R wave with a concomitant increase in the size of the Q wave was noted. When the electrode reached the level of the left auricle, patterns similar to left ventricular cavity potentials (as recorded in man by left heart catheterization and esophageal leads) were obtained.

6. The amplitude of the R wave in leads taken in the left lower bronchus is much higher in the anterior branch than in the posterior branch of this bronchus.

7. Compared with routine unipolar extremity and precordial leads in patients with normal hearts, the right bronchial leads RBa-1 and RBm-1 (in the anterior and middle secondary branches of the right lower lobe) reveal QRS patterns similar to lead aV_R. Lead RBp-1 (posterior secondary branch of the right lower lobe) records potentials similar to leads V7_R and V8_R. The left bronchial leads reveal in LBa-1 and LBm-1 (the anterior and middle secondary branches of the left lower lobe) a QRS pattern which resembles, but is not identical with, leads aV_L and V4 to V7. In LBp-1 (posterior secondary branch of the left lower lobe bronchus) the QRS patterns occasionally resemble those of V8 and V9.

8. The RS-T segment in bronchial leads may be elevated or depressed in cases where no RS-T segment alteration is present in routine standard and unipolar leads. The T waves are inverted in all right bronchial leads and usually inverted in left bronchial leads.

9. No arrhythmias were observed in any of the cases studied by bronchial exploration.

10. We believe that our procedure may be employed safely in selected cases, such as patients with chronic coronary insufficiency, previous intramural, high lateral, and small transmural infarcts where the findings in the classical electrocardiogram do not coincide with the clinical diagnosis. The advantage of this method...
is that it provides information as obtained partially by cardiac catheterization and esophageal exploration, and that it affords the unique opportunity of exploring widely the surface of the left ventricular wall.

**Acknowledgment**

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Unipolar Bronchial Electrocardiographic Exploration of the Heart in Man: A Preliminary Report*

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