The Bronchoscopic Measurement of Left Auricular Pressure

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A specially adapted needle on the end of a Jackson's suction tube has been used to pierce the left auricle of the heart through the upper end of one of the main bronchi. Pressure measurements and wave forms have been recorded in patients suffering from lung disease with normal hearts, in those with mitral stenosis and mitral regurgitation. This preliminary communication describes the method and shows some typical results.

The only chamber of the heart not so far accessible to direct pressure measurement has been the left auricle. The surgery of mitral stenosis has increased the need for information about the hemodynamics of the left auricle, and the present investigation was planned as a contribution to this end. Although much has been learned from the measurement of pulmonary capillary pressure, there has been no proof that this reflects all the changes that may occur in the left auricle. There has certainly been a need to investigate this, and the direct approach has therefore been undertaken.

The left auricle is so closely related to the esophagus behind, the bifurcation of the trachea above and the two bronchi on each side that these channels presented an obvious method of approach. Experience in the measurement of pressures in esophageal varices through the esophagoscope, and in the aspiration of congenital bronchial cysts through the bronchoscope had already been obtained, and it seemed an easy thing to apply this experience to direct puncture of the left auricle. Trials on the cadaver showed that it was equally easy to pass a needle into the auricle through the esophagoscope at a point about 30 cm. from the alveolar margin, or through the bronchoscope at the level of the carina or upper end of one of the main bronchi. The latter path seemed to be the cleaner one as swabs taken from this region where there is no obvious respiratory infection are always sterile. It was this approach, therefore, that was finally adopted for the living patient.

Anatomy

The bifurcation of the pulmonary artery lies anterior to the lower end of the trachea and the carina. Immediately below the bifurcation of the pulmonary artery lies the left auricle and as this bulges backwards into the concavity of the thoracic spine it lies between the two main bronchi. The superior pulmonary veins lie in front of the bronchi, and the inferior veins pass behind the bronchi. The line of the anterior wall of the trachea, if prolonged downward, would pass through the pericardium behind the pulmonary artery into the left auricle.

Apparatus

The apparatus consists of a standard membrane manometer filled with fluid to which a "catheter-like" tube and a needle are attached. The needle is fused to a metal bronchus-aspirating tube 50 cm. long and with 2 mm. bore, which is attached to the manometer by a length of rigid polythene tubing of 3 mm. bore. The length of the tubing is kept at a minimum, but a convenient length for ease of insertion is found to be 40 cm. (fig. 1).

The system was found to have an undamped natural frequency of 50 cycles a second, and although it is realized that components of the fundamental pulse wave oscillating at more than 25 cycles a second will not be recorded faithfully, it is considered that this factor will produce negligible distortion of the fundamental pulse wave itself, when the system is critically damped. Damping has been achieved by using the puncturing needle as the damping needle, this having the advantage of preventing free damped vibrations in the fluid system. The minimum length for insertion into the left auricle is 4 cm. so that the needle must be at least 5 cm. in length.

Critical damping was found by the method of Warburg,1 and in the present work a figure between

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0.7 and 0.8 has been accepted. The needles which complied with these requirements were approximately of 0.3 mm. bore and 5.5 to 6.0 cm. in length, and were most easily made from British wire gage, number 24 needles. Trial and error, with various needles, was thought to be a better way of finding optimum damping, than calculation, which would in itself require experimental proof.

Great care should be used in filling the fluid system, for a small air bubble will cause overdamped tracings. To show up such an error it is useful to apply a square wave impact immediately after setting up the apparatus and before each set of recordings. Vibration of the system must be prevented, and to this end efforts are now being made to eliminate the polythene tubing and use the needle manometer system as a single rigid instrument.

Technic

The patient is given 10.0 mg. morphia and 0.6 mg. atropine for premedication. The throat and larynx are painted with 2 per cent Amethocaine hydrochloride and a few drops of this are instilled into the trachea. The adult Negus bronchoscope is passed down to the carina and this too is sprayed with the local anesthetic. A swab has been taken from the medial wall of the right main bronchus for bacteriologic examination, and this, so far, has always been sterile. The needle on the cannula, connected to the manometer and filled with saline-heparin solution, is introduced into the bronchoscope, and, with the solution dripping, it is passed through the anteromedial wall of the right main bronchus at the carina (fig. 2). The needle passes about 4 cm. before entering the auricle but this depends a little on the size of the chamber.

Results

The present communication is mainly to describe a simple technic for measuring left auricular pressures rather than to draw conclusions from the small number of results so far obtained. The following preliminary observations have been made: (1) Bronchoscopic measurement of left auricular pressure in control patients suffering from some disease other than mitral stenosis for which a thoraco-
omy was to be done (fig. 3 A); (2) comparison of the pressures and wave forms obtained by puncture through a bronchus in control subjects with those obtained by direct puncture of the left auricle at thoracotomy, using the patients suffering from mitral stenosis (figs. 6 and 7).

Samples of the tracings are presented. Although these electrocardiograms and phonocardiograms were recorded simultaneously

![Figure 3](image3.png)

**Fig. 3.** Normal heart. Carcinoma of bronchus. Upper record, electrocardiogram. Lower record, left auricular pressure. Paper speed 25 mm. per second. Calibration in cm. H$_2$O. Same manometer system used in each recording.

(A) Obtained through the right bronchus. Arterial blood pressure 140/80. Zero leveled to manubrium sterni, patient supine. (B) Direct measurement through the open chest at operation. Arterial blood pressure 115/70. Zero leveled to mid left auricle, patient on left side.

![Figure 4](image4.png)

**Fig. 4.** Mitral stenosis. (A) From above down, records are phonocardiogram, electrocardiogram and left auricular pressure (obtained through right bronchus). Arterial blood pressure 120/80. Zero leveled to manubrium sterni. Paper speed 50 mm. per second. (B) Upper record, electrocardiogram. Lower record, left auricular pressure by direct puncture through open chest at operation. Arterial blood pressure 85/50. Zero leveled to mid left auricle, patient on right side. Both tracings show a little mechanical interference due to oscillation of the polythene tubing.

The same manometer system was used in each recording. Calibrations are in cm. H$_2$O.

same needle-manometer system (fig. 3 B); (3) repetition of the above observations in patients with mitral stenosis (fig. 4); (4) repetition as above in patients with mitral regurgitation (fig. 5); (5) simultaneous recording of left auricular pressure and pulmonary capillary pressure in with the left auricular pressures, they have been separated and remounted in order to save space. These are necessarily selected ones. Many more have been done during the experimental period. Their main value has been to show how distortion and interference can
Fig. 5. Mitral regurgitation. Upper record, electrocardiogram, lower record, left auricular pressure. Paper speed 25 mm. per second. Calibration in cm. H₂O. Same manometer system used in each recording.

(A) Obtained through the right bronchus. Arterial blood pressure 135/90. Zero leveled to manubrium sterni, patient supine. (B) Direct measurement through the open chest at operation. Arterial blood pressure 105/80. Zero leveled to mid left auricle, patient on right side. This record shows mechanical interference due to oscillation of polythene tubing.

Fig. 6. A and B. Anteroposterior and lateral radiograms of the chest of a patient with mitral stenosis, showing the cardiac catheter jammed in the periphery of the pulmonary vessel, and the bronchoscopic needle in the left auricle of the heart. Tip of needle is indicated by arrow. Simultaneous records are shown in figure 7.

occur, and what factors are mainly responsible for these. Difficulties arise from doing such work in unscreened rooms in a big general hospital where diathermy sets and short wave therapy are in constant use. In recent work the obvious advantage of simultaneous electrophonograms as well as electrocardiograms has been appreciated. No harm has come to any of the patients examined. Where operation has been performed, no trace of the puncture has been seen, except in one patient with huge pulmonary arteries and a pulmonary pressure equal to her systemic pressure. In this patient the pulmonary artery was punctured by passing the needle too far forward, and at operation there was slight excess of pericardial fluid, which was blood stained.

The only opinions that seem tenable at this stage of the investigation are: first, that the pressure tracing in the left auricle in a normal individual consists of a smooth double wave; second, that any subsidiary waves are caused by extraneous interference; third, that the wave form in mitral stenosis is similar to that in the normal, but that absolute pressures may be raised, and that this is so whether the auricle is fibrillating or not; fourth, that in gross mitral regurgitation the second wave climbs above the first with only a slight depression between the two; and fifth, that although the wave form in the left auricle may in certain circumstances be similar to that in
the pulmonary capillaries, this is by no means always so, and that the catheter jammed in the periphery of the lung is an unreliable way of estimating what goes on in the left auricle.

It will be noted that as yet no claim can be made that small degrees of regurgitation can be detected, and it has not been possible to estimate the mobility of the valve cusps from tracings obtained. It is hoped that extensive use of the method combined with careful appraisal of the heart at operation may, in the future, give useful information before operation.

**Summary**

1. A method is described for direct measurement of the pressure in the left auricle by means of a needle introduced through the bronchoscope.

2. Some of the difficulties of establishing such a recording system are discussed.

3. Pressure wave tracings are presented from patients with normal hearts, mitral stenosis, and mitral regurgitation.

4. The pressure and wave form in the left auricle have been compared with those taken simultaneously from a catheter jammed in the periphery of a pulmonary vessel.

**Sumario Español**

Una aguja especialmente adaptada al terminal de un tubo de succión de Jackson se ha usado para penetrar la aurícula izquierda del corazón a través del terminal superior de uno de los bronquios mayores. Determinaciones de presiones y ondas se han registrado en pacientes padeciendo con enfermedad pulmonar con corazón normal y otros con estenosis mitral y regurgitación. Esta comunicación preliminar describe los métodos y muestra algunos resultados típicos.

**Reference**

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