The Electrocardiographic Pattern in Venous Air Embolism

WILLIAM A. DASHER, M.D., WILLIAM WEISS, M.D., F.C.C.P.
and EMIL BOGEN, M.D., F.C.C.P.
Olive View, California

Air embolism is one of the most fearful and fatal complications of pneumotheraphy in tuberculosis.1 Air entering the circulation in the course of artificial pneumothorax, generally proceeds by way of the pulmonary veins to the left side of the heart and thence to the systemic circulation, producing the characteristic symptomatology of organ ischemia or infarction especially myocardial or cerebral. Air entering veins other than the pulmonary veins, as in the course of artificial pneumoperitoneum, affects primarily the right side of the heart. Amounts of over 100 cc. of air in the right side of the heart cause obstruction to blood flow and dilatation with resultant ischemia of its musculature. Even smaller amounts may cause fibrin clots or thrombosis and obstruct cardiac blood flow.

These effects are reflected by the electrocardiogram as ST-T segment changes, arrhythmias, various degrees of A-V block and intraventricular conduction delay or bundle branch block. Although the diagnosis of air embolism is often obvious because of its dramatic symptoms, sometimes the clinical picture may be vague and misleading, especially when smaller amounts of air enter the circulation and the vital organs are little or not affected. The electrocardiogram in this instance may be helpful in differentiating air embolism from other complications and thus affords a valuable laboratory aid in diagnosis.

Most of the reported cases of air embolism have died so soon after the injection of air, that there has been no time to study the patient or to obtain electrocardiograms. Groedel2 reported that, in a woman who died 24 hours after peri-renal insufflation of air, an electrocardiogram taken before death showed complete A-V block with changes suggesting myocardial ischemia. Durant3 has reported that when air is injected experimentally, into the femoral veins of dogs, sharp inversion of the T wave takes place (first-stage ischemia), then ST segment deviations occur (second-stage ischemia, injury phase) and finally marked alterations of the QRS complexes indicate conduction changes which may terminate finally in intra-ventricular block and ventricular fibrillation.

Over 100 instances of air embolism following pneumoperitoneum have been reported in the literature, including nine cases at Olive View Sanatorium.4 Three cases of right-sided air embolisms with electrocardiographic tracings which illustrate right-heart involvement are presented here. Two of these patients survived the air embolism and the electrocardiogram returned to normal, while one who showed a right bundle branch block died with a mural thrombus following the air embolism.
Katz\(^5\) has called attention to a characteristic electrocardiographic pattern which he ascribes to heart strain, although there is still some dispute as to its exact significance. An inverted QRS or deep S wave in lead I, with an upright QRS in lead III, together with a depressed or inverted ST-T pattern in lead III and in the chest leads over the right side of the heart are usually attributed to right heart strain. \(P\)-pulmonale, indicated by a small \(P_1\) with peaked \(P_2\) and sometimes inverted \(P\) in the chest leads further points to right heart involvement.

**Figure 1A**: Normal electrocardiogram. *½ Stand.—Figure 1B*: Immediately after embolism.—**Figure 1C**: Electrocardiogram returning to normal six months later.
Figure 1 shows a normal electrocardiogram taken months prior to the patient's air embolism. A few hours following the acute episode of air embolism, an electrocardiogram (Fig. 1B) showed an increased cardiac rate, the appearance of a deep Sl, small Q3, elevated T26 and peaked P2,3, V1-6. A later electrocardiogram taken six months later shows a return to a more normal pattern but still with a high T26.

In Fig. 2 no previous electrocardiograms were available and a tracing taken a few hours after this patient's air embolism, shows a rapid
heart rate. In Fig. 2A the early changes of inversion of ST-T pattern in V<sub>1,2</sub> were noted. Twelve days later these T wave inversions extended to V<sub>1,2,3</sub>. Finally 26 days later, the electrocardiogram returned to a normal pattern completing the cycle of right heart strain.

In Fig. 3 an electrocardiogram was not taken until the day before death and shows a typical interventricular block of the concordant inverted type. The QRS interval is 0.12 seconds and is inverted in all limb leads. Autopsy performed the following day disclosed a large mural thrombus almost completely filling the right auricle and acting as a ball valve obstruction to cardiac blood flow.

The above three examples give clinical support to Durant's experiments in dogs and illustrate how the electrocardiogram may aid in the diagnosis of right sided air embolism.

Durant has also shown experimentally that placing the animal on its left side relieves the intra-cardiac obstruction of pulmonary air embolism.

FIGURE 3: Bundle Branch Block with mural thrombus and air embolism, proved by autopsy.
as the air trapped in the right ventricular outflow tract floats toward the apex of the right ventricle and the electrocardiogram returns to normal. The air in the right ventricle is then churned into small bubbles and passes to the pulmonary vessels to be excreted by the lungs. Placing the patient in the left lateral position with the head down may be even more effective since air is then shunted away from the head and into the lower portions of the body, thus avoiding a fatal cerebral air embolism.

If an electrocardiogram is taken early and the diagnosis of an air embolism is established, the patient may be properly positioned and treated and thus be saved from serious complications or death.

**SUMMARY**

Three cases of right sided air embolism with electrocardiographic tracings demonstrate characteristic electrocardiographic patterns of right heart strain due to air embolism. Because of the diagnostic value of the specific electrocardiographic pattern of right heart strain, the electrocardiograph should be used early and often as an aid in the recognition of air embolism.

**RESUMEN**

Mediante los trazos electrocardiográficos en tres casos de embolia gazeosa del lado derecho, se demostraron aspectos característicos de esfuerzo del corazón derecho debidos a esa embolia.

A causa del valor diagnóstico del aspecto electrocardiográfico específico, ese trazo debe usarse de inmediato y a menudo para el descubrimiento de la embolia gazeosa.

**RESUME**

Les tracés électrocardiographiques ont démontré dans trois cas d'embolie gazeuse du côté droit des images caractéristiques d'atteinte du cœur droit. Étant donné la valeur diagnostique des tracés électrocardiographiques caractéristiques de l'atteinte du cœur droit, l'électrocardiographie devrait être utilisée précocement et souvent, pour permettre de reconnaître l'embolie gazeuse.

**REFERENCES**