The venous samples in this study were most often identified by the lack of appearance of blood in the needle and bottom of the syringe without aspiration. This fact is carefully noted. On a few occasions the results were clinically questionable, that is, the PaO₂ being so low or the PaCO₂ increased to a level so unexpected that a repeat study was immediately obtained and the correct results substituted.

Indwelling arterial catheters are important in certain circumstances, as, for example, during the very frequent blood gas measurements needed with lung lavage or in some patients with hypotension and a poorly palpable pulse. However, the routine use of indwelling arterial catheters is not advocated; although a recent study of 70 patients with battle casualties from Vietnam who had long-term arterial catheterization showed good results. The need for close monitoring of the "arterial line" to avoid blood loss, in keeping the arm immobile so as to prevent the catheter from becoming dislodged, and the at least theoretic complications of ruptured or clotted arteries, large hematomas, and embolization are but some of the reasons that we feel repeated arterial punctures with the small-bore needle are advantageous.

REFERENCES

Anomalous Double Blood Supply to the Lung*

Philip J. Hofschire, M.D.; Edward P. Todd, M.D.; Richard L. Varco, M.D., F.C.C.P.; Edward L. Kaplan, M.D.; and Jesse E. Edwards, M.S., F.C.C.P.

We report an unusual case in which an apparently normal upper lobe of the right lung was supplied by major systemic arterial and pulmonary arterial vessels. The anomalous artery arose from the descending aorta. Following interruption of this vessel, the machinery-like murmur previously present disappeared.

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CHEST, 69: 3, MARCH, 1976

The lungs have a dual arterial system, the greater being the pulmonary arterial and the lesser the bronchial arterial pathways. Normally, the pulmonary arterial pathway supplies 98 percent of the pulmonary blood flow and the bronchial arteries the remainder.1,2 Despite the fact that the bronchial arteries are probably the major source of oxygenated blood during fetal development, at birth they are still diminutive in size compared to the pulmonary arteries and do not significantly enlarge from that time on. Flow is roughly proportional to arterial size.3

Increased bronchial arterial size and blood flow have been associated with acquired chronic pulmonary disease,4 pulmonary sequestration,5 arteriovenous fistula,6 and several forms of congenital cardiac disease,7 particularly those with pulmonary stenosis. We report herein a case in which the upper lobe of the right lung received its arterial supply both from a large bronchial artery and an apparently normal pulmonary arterial system, despite a normal pulmonary parenchyma. Since, to our knowledge, this case does not appear to fit into any of the categories previously recognized, its clinical, radiologic, and surgical findings appear to be a pertinent addition to the literature.

CASE REPORT

The patient was a four-year-old asymptomatic girl who was admitted for cardiac evaluation because of a murmur first noted when she was two years old. There was no history of congestive cardiac failure or of cyanosis.

On physical examination the patient was a healthy-appearing acyanotic girl in no distress. Her pulse was regular at a rate of 74 beats per minute; her blood pressure was 110/60 mm Hg, both in the upper and the lower extremities; and her temperature was normal. The thorax was symmetric. There was no precordial thrill, and the first and second cardiac sounds were normal. A grade 3/6 systolic-diastolic machinery type murmur was heard maximally at the second right intercostal space paraesthesia. The murmur radiated over the entire right side of the thorax. No abnormal breath sounds were noted. There was no hepatosplenomegaly or clubbing. The pulses in the extremities were palpable and of equal quality. Auscultation over the various major systemic arterial areas revealed no bruits. Findings from the remainder of the physical examination were unremarkable.

Laboratory studies showed the hemoglobin concentration to be 13 gm/100 ml of blood. The total leukocyte count and the results of urinalysis were normal. The thoracic roentgenogram revealed a normal-sized heart. The only abnormality in

<table>
<thead>
<tr>
<th>Site</th>
<th>Pressure, mm Hg</th>
<th>Oxygen Saturation, Percent</th>
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</thead>
<tbody>
<tr>
<td>Right lower lobe wedge</td>
<td>Mean, 10</td>
<td>...</td>
</tr>
<tr>
<td>Distal pulmonary artery</td>
<td>28/10 (Mean, 14)</td>
<td>77</td>
</tr>
<tr>
<td>Pulmonary trunk</td>
<td>28/10 (Mean, 14)</td>
<td>77</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>32/0-4</td>
<td>76</td>
</tr>
<tr>
<td>Right atrium</td>
<td>Mean, 6</td>
<td>77</td>
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<tr>
<td>Superior vena cava</td>
<td>...</td>
<td>78</td>
</tr>
<tr>
<td>Ascending aorta</td>
<td>100/60 (Mean, 82)</td>
<td>93</td>
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ANOMALOUS DOUBLE BLOOD SUPPLY TO THE LUNG 439
the pulmonary fields was evidence of increased vascular markings localized to the upper lobe of the right lung. The electrocardiogram was within normal limits.

During right cardiac catheterization, three complete oxygen saturation series were performed, each giving essentially the same results (Table 1). There was no step-up in oxygen saturation in the atrium, ventricle, or distal main right pulmonary artery. It was, however, not possible to obtain samples from the segmental pulmonary arteries of the upper lobe of the right lung. Pressures in the right ventricle, pulmonary artery, and right lower lobe wedge were all normal.

A pulmonary arteriogram was obtained (Fig 1) by pressure injection of contrast material into the pulmonary trunk. This showed a normal distribution of the pulmonary arterial tree. The levophase of this study revealed a large vessel which appeared to arise from the descending aorta and to proceed into the right upper pulmonary field. A selective aortogram was then obtained with the tip of the catheter positioned above the aortic valve. Beyond a normal left arch and a large branch arose from the descending aorta (Fig 2). The distribution of this vessel was solely to the upper lobe of the right lung. There was no definite evidence of communication between the systemic and pulmonary arterial circulations, and no arteriovenous communication was observed. The aortic blood was fully saturated with oxygen. Surgical division of the artery was advised.

At operation the thorax was entered through a standard right thoracotomy approach. Inspection of the right lung revealed a normal appearance to each of its lobes with full expansion and no evidence of cystic changes. Retraction of the right lung anteriorly revealed a large subpleural artery, varying from 6 to 8 mm in diameter, passing from the level of the fifth thoracic vertebra to the upper portion of the right pulmonary hilus. The vessel entered the upper lobe in the area of its posterior segment (Fig 3). The artery was dissected proximally beneath the esophagus to its origin from the descending thoracic aorta and distally into the parenchyma of the upper lobe of the right lung where it divided into five branches of equal caliber.

The individual branches of the anomalous vessel in the lung and the origin of the artery from the aorta were ligated and divided; the anomalous artery was then removed. The thorax was closed in routine fashion.

The postoperative course was uneventful. No murmur was audible either immediately after operation or at the time of follow-up six weeks after surgery. Histologic examination of the removed artery revealed the characteristics of a normal elastic artery (Fig 4).

**DISCUSSION**

In the case presented, there were both normal pulmonary arterial and anomalous systemic arterial blood supplies to the upper lobe of the right lung.

It is recognized that in acquired localized pulmonary disease, significant systemic arterial flow may occur into the region of the pulmonary lesion. The arterial sources are generally those of enlarged standard bronchial arteries.

In instances where a major systemic artery other than a standard bronchial artery supplies a portion of the lung, that portion usually exhibits sequestration. In this condition the sequestered segment does not exhibit continuity with the bronchial system and usually appears as
a mass visible in roentgenograms. In this case the surgical and radiologic observations indicate that the lobe receiving a major dual arterial supply was normal. The involved systemic artery arose from the lower descending aorta and was considered to be other than a standard bronchial artery.

Under the circumstances of our case with regular and assumed normality of the bronchopulmonary connections, one might consider that the anomalous artery was part of a bronchial arteriovenous fistula. There was no evidence for such a process. This leaves our case as a most unusual one in which an otherwise normal pulmonary lobe received a major dual arterial supply. The data at our disposal do not allow determination as to whether the termination of the systemic artery was into the pulmonary arterial or pulmonary capillary beds.

Rate-Dependent Premature Beats in Man*

Herman O. Klein, M.D.

Ventricular premature beats (VPBs) appeared in a patient afterpacemaker insertion for complete heart block secondary to acute myocardial infarction. Contrary to expectations, the frequency of VPBs was directly related to the basic pacemaker rate. The VPBs are either reentrant beats or represent VPBs arising from pacemaker cells with “slow-response” characteristics, which have been shown to become more automatic with increasing rates of electrical stimulation. This case documents the phenomenon of rate dependency of VPBs in man and discusses its practical importance.

Overdrive suppression is a well-known method of treatment for ventricular arrhythmias. It is distinctly unusual to observe instances in which ventricular premature beats (VPBs) are induced by a moderately rapid rate of pacing and are decreased or eliminated by a reduction in the rate of the pacemaker. This seemingly paradoxical response to electrical stimulation was first observed experimentally in digitalis toxicity and subsequently in isolated canine Purkinje fibers. This report illustrates its occurrence in man, demonstrating that it is of more than theoretic interest.

Case Report

Transvenous endocardial pacing was instituted in a 50-year-old man with complete heart block following acute myocar-

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CHEST, 69: 3, MARCH, 1976

Figure 4. Anomalous artery removed at operation. a Low power (elastic tissue stain, original magnification x 15). b Higher magnification shows evenly distributed layers of elastic tissue in media characteristic of elastic artery (elastic tissue stain original magnification x 210).