Editorial

The Direction of Blood Flow in Coronary Arteries Arising from the Pulmonary Trunk

In anomalous origin of one of the two coronary arteries from the pulmonary trunk, a particular concept regarding direction of blood flow has come into focus in recent years. This concept holds that the artery which arises from the pulmonary trunk does not carry pulmonary arterial blood into the myocardium. Rather, through collateral vessels between the two coronary arteries, blood is shunted from that artery which arises normally from the aorta into the anomalous artery and finally into the pulmonary trunk. Such a system would function as an arteriovenous fistula and make the myocardium ischemic.

In one of two cases reported elsewhere in this issue by Nadas and associates this concept was confirmed. Moreover, in this case of Nadas, as in similar ones reported, the fistula was successfully ablated by interruption of the anomalously arising coronary artery near its origin from the pulmonary trunk.

In the second of Nadas' two cases, on the contrary, the authors were unable to demonstrate flow of blood through the anomalous artery into the pulmonary trunk. There is, therefore, a dichotomy in functional effect among patients with the same anatomic arrangement as exemplified in Nadas' two cases. This led Agustsson and Gasul and their co-workers to expand on the concept of Gouley that there are two functional types of the anatomic entity in which one of the two coronary arteries arises from the pulmonary trunk.

That form with well-established communications between the two coronary arteries and with delivery of coronary arterial blood into the pulmonary trunk was called by Agustsson's group the adult type. When no such reversal of flow in the anomalous coronary artery could be demonstrated, the infantile type was said to be present.

Nadas and co-workers suggest that among patients with the anatomic entity under consideration there is a spectrum in functional states with the extremes represented by the two aforementioned types.

Use of the term "type" suggests to the reader that for a given patient the functional state is fixed. Agustsson and co-workers recognized that the functional difference between the two so-called types is dependent upon a difference in the state of intercoronary anastomoses. They suggested that this difference may be attributed to basic differences (among individuals) in the structure of the coronary arterial system at birth rather than "... to consequently developed collateral circulation..."
I would propose that in each patient with anomalous origin of a coronary artery from the pulmonary trunk there is a gradually changing functional pattern, that in a given patient the functional state identified at one time might differ from that at some future time.

In order to develop this thesis, as has been implied by Keith, it is proper to consider the coronary circulation in this anatomic entity as it relates to fetal life and the postnatal state.

The aortic and pulmonary arterial pressures of the fetus are essentially equal. Therefore, during this period each coronary artery would be perfused at essentially the same pressure. It must, therefore, be concluded that during fetal life in each instance of the anomaly, the pulmonary trunk is the source of blood to that portion of the myocardium supplied by the anomalously arising coronary artery (fig. 1a). During this period, as the heads of pressure are the same for each coronary artery, there would be no greater basis for development of collateral communications between the two coronary arterial systems than in the normal in which both arteries arise from the aorta.

After birth, the pulmonary arterial pressure falls below levels of systemic pressure. This places the anomalously arising coronary artery in a lower pressure compartment than is that artery which arises from the aorta.

It is probable that the development of collateral communications between the two coronary arteries depends upon differences between aortic and pulmonary arterial pressures. The well-developed collateral system that is observed in some patients must, therefore, be considered to have been acquired after birth and perforce must have become established gradually.

Keith, in one of five cases, and Talner, Stern, and Figley (according to Goldberger),

![Diagrammatic portrayal of varying functional states in anomalous origin of the left coronary artery from the pulmonary trunk.](image)

**Figure 1**

Diagrammatic portrayal of varying functional states in anomalous origin of the left coronary artery from the pulmonary trunk. a. During fetal life aortic (A.) and pulmonary arterial (P.) pressures are essentially equal. Flow in the anomalous artery is from the pulmonary trunk into the myocardium. b. Early postnatal life when pulmonary pressure has fallen below levels that pertain during fetal life. Rich intercoronary collateral channels have not yet developed. In this phase, flow through the anomalous coronary artery is probably at a low level. The anomalous vessel may be perfused either from the pulmonary trunk or from the right coronary artery through developing collateral systems. c. The final phase in which a rich collateral system has developed between the two coronary arteries. Characteristics of an arteriovenous fistula now pertain, with the major contribution to fistulous flow coming from the right coronary artery. Mediastinal arteries which make communication with the coronary arterial septum may also contribute to such flow.
in each of two cases, working with infants in whom this anomaly was present, demonstrated, by angiographic means, flow of pulmonary arterial blood into the anomalous coronary artery.

Such a direction of flow may perhaps pertain in all cases for a varying period of time after birth, while the pulmonary arterial pressure (though less than aortic) is still above stabilized postnatal levels. As the pulmonary arterial pressure continues to fall, however, the forward flow within the anomalous artery would be expected to fall. Lowering of the pulmonary arterial pressure would, in turn, also stimulate the development of collateral circulation between the two coronary arteries.

One may envision a transitional phase between the two principal phases of coronary arterial flow (fig. 1b). The first principal phase would be that in which the anomalous artery is supplied by the pulmonary trunk. In the second of the two principal phases, the anomalous artery, after development of rich collateral communication between the two coronary arteries, carries blood into the pulmonary trunk.

During the aforementioned assumed transitional phase, flow of blood into that part of the myocardium supplied by the anomalous artery might be at an all-time low level. A transitional phase might correspond to the time of onset of symptoms of myocardial ischemia. (It will be recalled that classically no symptoms are present until several months after birth.)

Following the full development of collateral vessels between the two coronary arteries the critical portion of the myocardium would receive its blood supply from the normally arising coronary artery (fig. 1c). During this phase, however, the very presence of a well-established collateral system between the two coronary arteries would favor run-off of coronary arterial blood into the pulmonary trunk. The myocardial ischemia present in this phase should be related to escape of coronary arterial blood through the fistula.

Support for the concept of changing phases in this anomaly comes from a report of Agustsson and co-workers.4 In a review of the literature these authors found that the youngest patient with the "adult type" of the anomaly was 16 years of age (their own two cases were 6 and 7 years old). These authors indicate that the patients exhibiting characteristics of the so-called infantile type are usually infants, although Sabiston, Neill, and Taussig10 observed flow from the right coronary artery through the left coronary artery into the pulmonary trunk of an infant only 2½ months old. Similar flow was demonstrated by Rudolph and associates11 in an 8-month-old infant. This suggests that there is an individual variation as to when rich intercoronary collateral communications develop but does not alter the concept of changing phases as opposed to fixed types.

If our reasoning is correct, it is logical to abandon the concept of fixed functional types among patients with anomalous origin of a coronary artery from the pulmonary trunk. It seems more appropriate to consider that there are phases in each patient. Obviously, definitive therapy in the form of interruption of the anomalous coronary artery is applicable to cases in which escape of blood into the pulmonary trunk is demonstrated. When, as in Nadas’ second case, no such channels are apparent, or where flow from the pulmonary trunk into the anomalous artery is demonstrated, such a procedure at that time would not be applicable. In the absence of some other appropriate definitive therapeutic procedure, it would be the hope that such a patient would survive to that phase in which a rich collateral system between the two arteries becomes established. At that time interruption of the anomalous artery would be indicated.

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References

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"The Methodology of Science"

When a man is talking about scientific subjects, the little word "I" should play no part in his expositions. But when he is talking about the purposes and aims of science, he should be permitted to speak of himself; for a man experiences no aims and desires so immediately as his own. The special aim which I have constantly kept before me is logical unification in the field of physics. To start with, it disturbed me that electro-dynamics should pick out one state of motion in preference to others, without any experimental justification for this preferential treatment. Thus arose the special theory of relativity, which, moreover, welded together into comprehensible unities the electrical and magnetic fields, as well as mass and energy, or momentum and energy, as the case may be. Then out of the endeavor to understand inertia and gravitation as having a unified character there arose the general theory of relativity, which also avoided those implicit axioms which underlie our thinking when we use special co-ordinate systems in the process of formulating basic laws.—Albert Einstein. Essays in Science. New York, Philosophical Library, Inc., 1934, p. 113.
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