Blood Supply of the Human Interventricular Septum

By THOMAS N. JAMES, M.D., and GEORGE E. BURCH, M.D.

The blood supply of the interventricular septum has been studied in 43 normal human hearts, from patients dying of noncardiac causes. The specimens were prepared by injection of vinylite into the coronary arteries. Description is made of the normal vascular anatomy of this area, and its clinical importance is discussed.

ALTHOUGH the interventricular septum comprises a large portion of the myocardium, study and description of its normal blood supply have been neglected; one standard textbook of anatomy fails even to mention it.1 This lack of attention may be attributed to its relative inaccessibility for anatomic studies without disturbing its structural relationships. Injection of colored opaque solutions, followed by clearing in various oils, fails to display the interventricular septum adequately.2,3 Stereoscopic roentgenograms of injected coronary arteries result in overlapping of septal vessels to such an extent that their individual identification becomes difficult, if not impossible.3 "Unrolling" the heart before the roentgenograms are taken4 isolates the septum but also removes it from its spatial orientation.

Laubry, Soulié, and Thys5 injected radiopaque material into the coronary arteries and then obtained roentgenograms of the isolated interventricular septum, whereas Hermanek6 examined the blood supply of this region by dissection alone; both these studies, however, were concerned primarily with infarction and coronary anastomoses in the septum.

For examination of the normal blood supply of the heart a more satisfactory method is injection of a noncorroding substance into the arteries, followed by corrosion of the supporting structures to leave a cast of the arteries. Additional casts of the cardiac chambers result in a spatially oriented replica of the entire heart.7 Casting of the chambers of only one side of the heart makes possible examination of the vessels in the interventricular septum. This method was employed in the present study to obtain information regarding the normal blood supply of the human interventricular septum.

MATERIAL AND METHODS

Forty-three human hearts, of patients (32 men and 11 women) who died of noncardiac causes, were examined. Ages ranged from 12 to 81 years, with similar frequency distribution in each decade except for the eighth and ninth decades of life, which contained 1 patient each.

These hearts were normal in weight and the ventricles on gross inspection were not hypertrophied. In all hearts the valves were examined under direct vision through the aorta, main pulmonary artery, venae cavae, and pulmonary veins; in this series none of the hearts had pathologic valves. The coronary arteries were inspected at their ostia prior to cannulation, and for their entire length where visible in the epicardium; the arteries of all hearts in the series were patent for their visible length and none exhibited atherosclerosis of a degree indicative of compromising blood flow. The hearts and other gross organs of these patients were normal in color (specifically no remarkable pallor), but antemortem hematologic data were not available. There were no gross lesions of the myocardial surface, such as fibrosis or infarction.

The arteries were injected with vinylite resin, and the tissue was subsequently removed with concentrated hydrochloric acid, according to a technic previously described.8 Although casts of either the right or left ventricles were made in various hearts, casts of the right chambers resulted in better retention of the normal shape of the heart.

RESULTS

The interventricular septum of man receives most of its blood supply from the left
Fig. 1. Photograph of the right lateral aspect of the vessels in the interventricular septum. See figure 2 for anatomic orientation. Branches of the right coronary artery (the dark undulating trunk crossing the upper heart) have been cut off to reveal the septum. The lighter vessels on the right side of the photograph are the left anterior descending coronary artery and its septal branches. On the left side of the photograph may be seen the short septal branches of the posterior descending coronary artery, which are darker. The lighter vessel, which has a wrinkled appearance, at the extreme left margin is the posterior interventricular vein.

Posterior descending coronary artery (figs. 1 and 2). These septal arteries from the anterior interventricular sulcus were usually 40 to 80 mm. in length. They coursed diagonally in an anteroposterior direction, slightly caudally, describing a gentle curve with convexity to the right. The anterior descending artery was well developed in all hearts, and comprised the only branch of the left coronary artery in 2 hearts. It always reached the apex cordis and in most hearts coursed around onto the lower posterior interventricular sulcus, ascending for a distance of 10 to 50 mm.

The anterior penetrating septal arteries entered from the epicardium near the right ventricular side of the septum and remained near the right ventricular endocardium for the initial part of their septal course (fig. 3). These long penetrating arteries terminated in a relatively straight direction, as opposed to the right angle terminal branching of the arteries of the free wall of the left ventricle. The penetrating septal branches of the posterior descending coronary artery (the terminal right coronary artery in 41 of the 43 hearts) were relatively short, seldom being more than 15 mm. in length.

In the upper portion of the septum posteriorly, the right coronary artery made a unique U-turn deep to the posterior interventricular vein, to penetrate the junction of the interventricular and interatrial septa in the region of the atrioventricular node (figs. 2 and 4). At this point the right coronary artery gave off a relatively large branch from the apex of the U-turn, which continued for a distance of about 25 mm.

Gross anastomoses were found within the interventricular septum between the right and left coronary arteries. In the free walls of the ventricles adjacent to the septum anas-
BLOOD SUPPLY OF THE INTERVENTRICULAR SEPTUM

FIG. 3. Left, a planar diagram of the contour of the human interventricular septum as viewed from the right ventricular side. The long arrows point to cross-sections from the corresponding levels in the planar diagram. In the section from the upper septum are seen the longest septal branches of the posterior descending artery. From the mid-septum (the muscular portion) the cross-section illustrates the predominance of supply by the anterior penetrating arteries. The cross-section near the apex depicts both the anterior and posterior septal branches as derived from the left anterior descending artery, since this artery passes around the apex to the posterior wall. In all the cross-sections note the proximity of the septal branches to the right ventricular endocardium and the lack of perpendicular terminal branching which is characteristic of terminal arteries in other areas of thick myocardium.

tomoses could also be seen communicating with the main arterial trunks overlying the septum. The anastomoses most frequently found were located in the following sites:

1. Between the anterior and posterior penetrating septal arteries, particularly in the midportion of the septum.

2. Between the upper 2 cm. of the left anterior descending artery and the first 2 cm. of the right coronary artery by way of the ring of Vieuissens (fig. 5), and between right ventricular branches of the left anterior descending artery and the straight branches of the right coronary artery.

3. Between the left anterior descending artery and the posterior descending artery around the apex cordis.

4. Between the posterior descending coronary artery and branches of the right marginal and left marginal arteries crossing horizontally over the posterior wall of the heart.

5. Between small arteries (in 2 hearts) behind the aorta, connecting the initial centimeter of the right coronary artery and the main left coronary artery.

One heart exhibited a large unusual branch of the right coronary artery in the first centimeter of its origin that turned in an opposite direction to the main right coronary artery, coursed behind the aorta caudally, turned anteriorly deep to the main left coronary artery, and reappeared in the midportion of the anterior interventricular sulcus. Throughout its course it distributed branches to the interventricular septum.

In addition to the penetrating branches from the anterior and posterior descending arteries, other branches from neighboring arteries in the free ventricular walls frequently coursed over to the anterior and posterior interventricular sulci, turned 90 degrees, and penetrated the septum for various distances. These branches were not large or numerous but may represent potential channels for collateral circulation. Such branches originated anteriorly from the left circumflex artery, the left straight arteries, and the left marginal artery; they originated on the posterior surface from both the right and left marginal arteries.

The variation in number, length, and courses of the anterior penetrating septal arteries was too wide to permit descriptive classification. In general the fewer the branches, the larger they were.

The origin of arteries to the interventricular septum was estimated to be in about the following proportions:

1. In 7 hearts, 60 to 70 per cent of the septal blood supply was provided by branches from the left anterior descending artery, and the remainder by branches from the posterior descending artery.

2. In 9 hearts, 70 to 80 per cent was provided from the anterior descending artery.

3. In 15 hearts, 80 to 90 per cent was provided by branches from the anterior descending artery.

4. In the remaining 12 hearts, 90 to 100
per cent was provided from the anterior descending artery.

Of this latter group of 12 hearts, the posterior descending artery of 2 of them was the termination of the left circumflex artery, so that the left coronary artery thereby supplied all the septum. In a third heart of these 12, the termination of the posterior descending branch of the right coronary artery was so poorly developed that it was distributed to only about 5 per cent of the interventricular septum.

The venous drainage of the ventricular septum was bidirectional. The larger and more numerous veins drained anteriorly into the left anterior interventricular vein; the remainder of the blood drained posteriorly into the posterior interventricular vein. Both of these channels emptied into the coronary sinus, although the juncture of the posterior interventricular vein was always extremely near the entrance of the coronary sinus into the right atrium. Unlike the coronary arteries, the veins communicated freely on the surface of the heart. For this reason, venous blood from the septum may sometimes reach the right anterior cardiac veins by way of branches of the left anterior interventricular vein and empty directly into the right atrium, separate from the coronary sinus.
Discussion

The blood supply of the human interventricular septum is vital for the maintenance of normal cardiac conduction. Since the septum contains the main trunks of the conduction system, interference with septal circulation, as from coronary occlusion, would be expected to result in defective conduction. Furthermore, cardiovascular operations involving the interventricular septum require familiarity with the vascular anatomy of this area.

The extent to which the blood supply of the human interventricular septum is derived from the left anterior descending coronary artery is not generally recognized. Since the thickness of the normal free left ventricular wall is approximately 12 mm. and since the posterior penetrating septal arteries (except near the atrioventricular node) rarely exceed 15 mm. in length, it seems highly unlikely that the septal branches of the posterior descending artery contribute a significant amount of blood to the ventricular septum. The greatest ultimate value of these posterior penetrating arteries may be as a source of potential collateral circulation.

In 41 of the 43 hearts in this study the posterior descending artery was the termination of the right coronary artery and supplied a significant portion of the posterior wall of the left ventricle. This finding differs from Schlesinger’s description of the blood supply of this area, in which the right coronary was less important.9

The interventricular septum and its conduction system may be divided into 2 areas. The upper portion, which includes the atrioventricular node, the bundle of His, and the upper segments of the 2 main bundle branches, was supplied in 40 (over 90 percent) of the hearts in this series by a branch of the right coronary artery that passed under the posterior interventricular vein (figs. 2 and 4). Embryologic significance of the course of this particular branch of the right coronary artery has been discussed previously.8

The second or lower area of the interventricular septum comprises the greater mass of the septum, including most of the 2 main bundle branches and the Purkinje arborization of the septum. This area was supplied mainly by penetrating branches from the left anterior descending coronary artery.

From this arbitrary division it is apparent that occlusion of the right coronary artery may be associated with disturbances in atrioventricular conduction (various degrees of block). Occlusion of the left anterior descending artery may produce bundle-branch block or free-wall (“arborization”) block. These deductions depend upon the efficiency and extent of collateral circulation.

The potential channels for collateral circulation are most numerous in the interventricular septum. Communications in the septum afford collateral flow between the 2 major coronary arterial trunks to compensate for occlusion of either. How frequently the anastomoses described in this study will occur in the septum of any given human heart can, of course, only be conjectured; in general, however, the more satisfactory the casting was from a technical standpoint, the more numerous were the anastomoses demonstrated. In this study of normal hearts several from the third and fourth decades of life exhibited numerous areas of gross anastomosis.

Since penetrating branches from the left anterior descending coronary artery to the septum are always multiple (figs. 1 and 2), occlusion of one or more of these may well be responsible for some of the obscure clinical cardiac states such as “spontaneous” bundle-branch block or the electrocardiographic syndrome of septal fibrosis.10

The interesting observation that the anterior septal arteries travel initially near the right ventricular cavity may be related to the lower pressure in that chamber. The arteries supplying the free wall of the left ventricle also tend to remain away from the high pressure within that chamber, traversing the epicardium until they reach the area to be supplied with blood, whereupon they penetrate perpendicularly into the myocardium.
Summary
The blood supply of the human interventricular septum has been studied in 43 normal hearts prepared by injection of the vessels with vinylite, followed by corrosion of the tissues with concentrated hydrochloric acid. The major blood supply of the ventricular septum was found to be derived from diagonally penetrating arteries entering from the left anterior descending coronary artery. Branches from the posterior descending coronary artery supplied only a small zone of the ventricular septum near the posterior interventricular sulcus and the region of the atrioventricular node. The interventricular septum is an important site of collateral circulatory channels in the human heart.

Acknowledgment
We are grateful to Drs. William Eckert, Wallace Clark, and Nicholas Chetta for their assistance in this study.

Summario in Interlingua
Le provision de sanguine in le septo interventricular del homine esseva studiate in 43 cordes normal, preparate per (1) le injection de vinylite in le vasos e (2) le subsequente corrosion del histos per medio de concentra acido hydrochloric. Esseva trovate que le major provision de sanguine in le septo interventricular es derivate ab arterias que penetra diagonalmente veniente ab le descendente arteria coronari sinistro-anterior. Brancas ab le posterior arteria coronari descendente ali-

References
Blood Supply of the Human Interventricular Septum
THOMAS N. JAMES and GEORGE E. BURCH

Circulation. 1958;17:391-396
doi: 10.1161/01.CIR.17.3.391
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1958 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/17/3/391

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/