ANEURYSM OF THE MEMBRANOUS SEPTUM PROJECTING INTO THE RIGHT ATRIUM

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THREE FIGURES

While studying the anatomy of the heart there came into my possession quite a rare specimen in which there was a cystiform aneurysm at the junction of the aorta with the left ventricle. It involved the membranous septum, burrowed into the anterior part of the medial cusp of the tricuspid valve, and projected into the right atrium (fig. 1). The heart was greatly hypertrophied, the muscle being very well developed. The septum of the ventricle was displaced to the left, that is, it had not shifted sufficiently to the right in development, thus possibly accounting for the aneurysm.

In his great work upon the defects of the septum[1] Rokitansky considers anomalies of this kind as due to endocarditis, a view which is not entertained to so extreme a degree by v. Buhl in a subsequent study.[2] From a perusal of the literature, which is well given by these two authors, as well as from a study of the development of the membranous septum of the human heart, I am inclined to the opinion that the aneurysm in my specimen is due not to endocarditis but to a weakness in this region on account of the misplaced septum of the ventricle.

In the normal heart the septum of the ventricle marks the left border of the aorta as may easily be observed by inspecting the cavity of the left ventricle through the aorta. This is also easily demonstrated by 'coronal' sections through the heart as

[1] Rokitansky, Die Defecte d. Scheidewand des Herzens, Wien, 1875.
[2] von Buhl, Zeitschrift f. Biologie, Bd. 16, 1880.

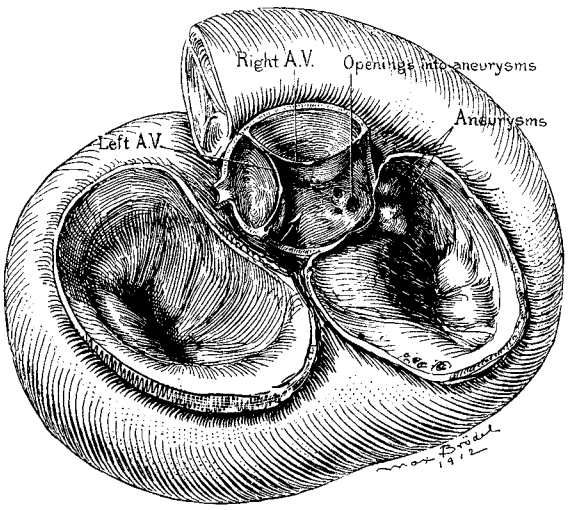

Fig. 1 Base of the heart. Three-fifths natural size. The posterior semilunar valve has been removed from the aorta to show the aneurysm. The right and left aortic (semilunar) are marked.

may also be seen in figures given by Quain, Toldt and Spalteholz. Often, however, the fleshy inferior septum protrudes a little and in such specimens the right semilunar valve (BNA) is attached to it as is normally the case in the ox and the pig. In the specimen under discussion the semilunar valve does not reach to the fleshy septum (fig. 2), the membranous septum extends, not upward, but toward the right, to reach the right side of the root of the aorta. In so doing this portion of the heart wall is weakened, and this may account for the bulging of the membranous septum first into the medial cusp of the tricuspid valve and thence into the atrium. Subsequently this aneurysm might rupture into the right atrium to produce a direct communication between the left ventricle and right atrium as described by Rokitansky and by von Buhl.

At the attachment of the aorta to the heart there is the well known space, which does not empty itself in systole, the space into which the semilunar valves project in diastole according to Henle, called the 'vestibule' in Quain's Anatomy, but not

especially designated in the BNA. This space is relatively much larger in the embryo especially while the interventricular foramen is still present. In studying the development of this region I found it convenient to retain the name 'vestibule' for the space in the ventricle from which the aorta rises. This point is brought out in some detail and illustrated in a study on the development of the heart which will be published shortly in The American Journal of Anatomy.

The aorta in its development must shift from the right side of the heart to the left and after it has gained its permanent

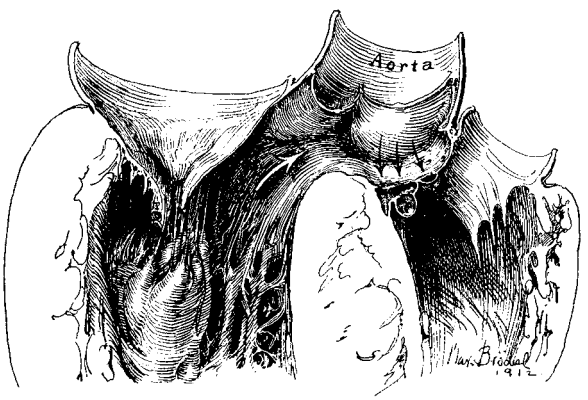

Fig. 2 Section through the heart showing the attachment of the aorta and the aneurysm. Three-fifths natural size.

position the inferior septum blends with its right side, forms the membranous septum, and completes the wall between the left ventricle (vestibule) and the right ventricle. In so doing the inferior septum must shift from left to right while the aorta is shifting from right to left. When this shifting does not complete itself the aorta remains in free communication with the right ventricle, or arises from it, and the interventricular foramen remains open. In such cases the vestibule of the adult remains identical with that of the embryo.

It is generally believed that the septum of the ventricle grows upward from the apex of the heart to unite finally with the

septum intermedium. This method of expression has been challenged by Flack[3] who asserts that the inferior septum is formed by the downgrowth of the two ventricles whose adjacent walls unite secondarily. Finally the cleft makes the notch between the right and left ventricles at the apex of the heart. This view I am able to corroborate. In the heart of an embryo 2 mm. long (no. 391) the canal connecting the two ventricles (ventricle and bulb) is 0.1 mm. in diameter. In an embryo 3.5 mm. long no. 164) it is still but 0.1 mm. in diameter, but in one 3.9 mm. long (no. 463) it is 0.15 mm. in diameter and within it there is a small ridge of tissue, the beginning of the septum inferior. In a specimen 8 mm. long (no. 113) the ventricles are well formed and the interventricular foramen is 0.3 mm. in diameter. At 11 mm. (no. 353) the foramen has reached its maximum size, being 0.4 mm. in diameter, but the septum inferior has extended far down with the growth of the ventricles and there is a cleft apex as is so frequently seen in embryonic hearts.[4] So at first the upper border of the septum grows away from the base of the heart and not towards it. The upper portion of the septum appears first and is therefore its oldest part; in its subsequent development the septum becomes larger by the downward growth of the ventricle. Later the enlarged interventricular septum is closed by the union of the inferior septum with the left wing of the septum intermedium, thus forming the membranous septum just below the medial cusp of the tricuspid valve.

It is apparent from this description that the interventricular foramen is at first gradually enlarging while the aorta is shifting from the right to the left side of the heart. At the same time the right side of the septum intermedium is projecting into this opening, for from it the medial cusp of the tricuspid valve arises. Ultimately this portion of the septum intermedium comes to ride on the posterior part of the septum inferior with the atrio-ventricular bundle between them. This leaves the aorta in front and to the left of the medial cusp of the tricuspid valve with

[3] Flack, In the Further advances in physiology, Longmans, New York, 1909.
[4] Mall, Anatomical Record, vol. 6, 1912.

the communication from the vestibule of the aorta to the right ventricle under the cusp exactly along the line of the right limb of the atrio-ventricular bundle in the adult. The left half of the septum intermedium remains free and is transformed directly into the anterior cusp of the mitral valve. By a subsequent shifting the posterior semilunar valve of the aorta becomes attached to the septum intermedium and does not remain upon the inferior septum as is the case in the heart pictured in fig. 1.

The membranous septum should, therefore, lie just below the anterior end of the medial cusp of the tricuspid valve as illustrated in the atlases of Spalteholz and Toldt and not above it, as stated by Quain.[5] In fact its usual portion is as shown in Spalteholz and Toldt but in exceptional cases the valve becomes adherent to the membranous septum and therefore it appears to be above the base of the valve, that is, between the vestibule of the aorta and the right atrium.

In the specimen under consideration the septum inferior is too far to the left, that is, it should have shifted more to the right. When viewed through the aorta (fig. 1) the septum covers half of its origin and the membranous septum is not in a perpendicular but in a horizontal direction (fig. 2). The horizontal septum naturally becomes the weak portion of the heart, and this may account for the numerous holes through it communicating with the sacs within the medial cusp of the tricuspid valve, as well as, bulging directly into the right atrium. The membranous septum is cribriform. The hypertrophy of the muscle of the heart may be due to the general muscular development of the cadaver from which this specimen came and not to the aneurysm. In the course of time the vigorous heart would favor the rupture of the aneurysm into the right atrium.

Merkel[6] describes a case in which together with an interventricular opening there was an aneurysm from the left ventricle

[5] Quain, vol 2, 1892, erroneously marks with a star the membranous septum in fig. 310. What he has thus marked is really the septum intermedium connecting the mitral and tricuspid valves. The membranous septum lies anterior to this star and is therefore not to be seen in this figure. The text on p. 365 is also incorrect.

[6] Merkel, Virchow's Arch., vol. 48, p. 488.

into the medial cusp of the tricuspid valve. Zahn[7] describes a similar case with multilocular aneurysm into the same valve. In this case there was a displaced fleshy septum as in my specimen. Zahn gives a second case with the inferior septum projecting into the vestibule of the aorta. In this there were several aneurysms from the vestibule through the membranous septum into the tricuspid valve, one of which protrudes into the right atrium, and another projects deep into the septum of the ventricle, as is also the case in fig. 2. In neither of Zahn's cases was any endocarditis present. Rokitansky gives a similar case (fig. 46) with marked protrusion of the ventricular muscular septum into the vestibule of the aorta. This heart was enlarged and there was no endocarditis. In this case there were numerous communications between the left ventricle and the right atrium. Von Buhl describes several cases of aneurysm and rupture of the membranous septum with acute endocarditis. One of his cases (fig. 16) of long duration, had a large communication between the left ventricle and right atrium, together with an opening into the right ventricle, as well as a small unruptured pocket. There was cicatricial thickening around the openings. It is impossible to determine from von Buhl's description whether or not the inferior septum projects into the vestibule of the aorta as in the other case of this catagory. However, von Buhl is of the opinion that his case is due to endocarditis, although he admits that the endocardial thickening may be of secondary origin.

MacCallum[8] describes a similar specimen. One of his specimens which I have had the opportunity to study (fig. 3), shows a complete hollowing of the anterior tip of the medial cusp of the tricuspid valve with a projection below the valve behind this. The distended valve projects into the right atrium and the muscular inferior septum is immediately below the opening of the aorta. The valves are smooth and transparent, no indication of endocarditis being present. The degree of distention of the valve is in advance of that in my specimen. Here again

[7] Zahn, Virchow's Arch., vol. 72, p. 206.

[8] MacCallum, Johns Hopkins Hospital Bulletin, no. 108, March, 1900.

the inferior septum is displaced to the left, thus weakening the membranous septum which must have been placed in a horizontal position.

In my own case the mitral and tricuspid valves were somewhat thickened but not sufficiently to warrant calling the condition due to endocarditis. Certainly there was no acute endocarditis present. However, from all that I can ascertain this type of anomaly can properly be traced back to an embryonic arrest of development in which the inferior septum did not move to the right sufficiently far but remained within the vestibule of the aorta as is the case normally in the ox and the pig. Most of

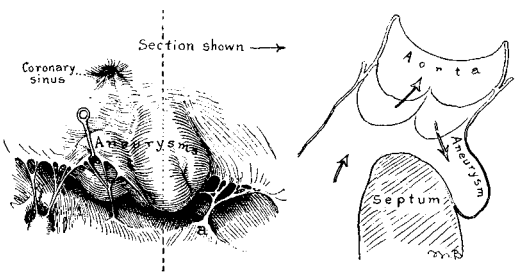

Fig. 3 MacCallum's specimen. One-half natural size. The protrusion of the aneurysm into and below the medial cusp of the tricuspid valve and a diagrammatic section through it are shown.

the cases enumerated above had in them the same anamolous position of the inferior septum. As a result of the misplaced inferior septum the membranous septum develops improperly and becomes placed in a horizontal and not in a perpendicular position. So it is weakened in every way and this predisposes to the formation of aneurysms. Normally the membranous septum lies below the tricuspid valve but a slight distortion may place the origin of the medial cusp of the tricuspid valve upon the membranous septum and as aneurysm from it would naturally invade this valve. The point of union of the medial and anterior cusps anteriorly marks the end of the septum aorticum posteriorly, so any projection over this line extends into the right atrium, a direction which is naturally favored on account of the low pressure in the atria when the ventricles contract.

The conclusion is that aneurysms of this variety are due not to endocarditis but to an anomalous position of the aorta which misplaces the membranous septum into a horizontal position, In both specimens studied, as well as those described in the literature, the inferior septum is displaced to the left and the aorta to the right.

BOOKS RECEIVED

TEXT BOOK OF MICROSCOPIC ANATOMY, Edward Albert Schäfer, 1001 illustrations and 21 colored plates, 739 pages including index, 1912, $7.50, Longmans, Green & Co., New York.

Extract from Preface: The present part of Quain's Anatomy is intended to serve as a Text-Book of Microscopic Anatomy. With this view, the subject-matter has been re-arranged and re-written, and a large number of new figures added. Many are original, the rest are from various sources.

The chapter dealing with the structure of the Vascular System is by Professor G. Mann of Tulane University, New Orleans.

The Index has been prepared by Dr. John Tait of Edinburgh University, who has also assisted in reading the proofs.