A CARDIOVALVULOTOME.

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Plates 14 and 15.

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The instrument and the operative procedure described here were developed with the purpose of establishing a surgical method applicable to the treatment of mitral stenosis.

With the same intention investigators during the past 20 years have developed methods for creating valvular insufficiency in animals. Cushing and Branch (1), Haecker (2), and Schepelmann (3) used small knives and hooks on long handles which were thrust into the ventricles and manipulated to slit or tear out valve cusps. Tuffier and Carrel (4) developed an extracardiac method consisting of suturing a piece of vein over the region of the pulmonic orifice, then dividing the ring with fine scissors slipped beneath this covering, thus allowing the support of the valve cusps to bulge outwards and produce an insufficiency. Recently Allen and Graham (5) have used an endoscope carrying a small knife with which the valves can also be divided.

Application of such methods to cases of mitral stenosis in man is limited to three attempts. The first was by Tuffier (6), who in 1912 attempted to stretch the stenosed aortic valve in a young man by introducing a finger into the stenosed ring through the invaginated wall of the aorta. The second was by Doyen (7), who unsuccessfully attempted to section the stenosed mitral valve, death being due to a lesion in the interventricular septum. The third is the case reported by Cutler and Levine (8) in which an attempt was made to section the stenosed mitral valve with a knife inserted through the left ventricle.

When the condition of stenosis in cases of chronic valvular disease is considered, the degree of obstruction, the thickness of the valve, its fibrous and often calcareous condition, it is at once apparent that such a valve, if valve it may be called, cannot be sectioned satisfactorily by a force applied to a knife several inches from the cutting edge without the aid of counterpressure applied to the valve at the point where the section is to be performed. The toughness of such a valve is so marked in some cases that, indeed, even scissors with

delicate blades are unable to section the valve under direct vision. It seems, furthermore, that a slit-like cut in the markedly thickened valve, on account of the stiffness and the rigidity of the incised margin, may relieve the functional obstruction but little, and that the excision of a piece from such a valve with its removal from the blood stream is almost a necessity if the obstruction is to be relieved. It seems essential, therefore, that a powerful cutting device be employed which will actually excise a piece from the stenosed ring and remove the piece from the blood stream (Fig. 1). A valvulotome has been devised which may aid in the accomplishment of this aim.

In the development of the instrument two guiding principles were accepted from the beginning as a necessity; namely, the principle of cutting by counterpressure and the application of force in a line parallel to the axis of the instrument by telescoping the handle. This latter principle makes the instrument straight and helps greatly in localization when the instrument is in the heart and when the sense of position is so important. In utilizing the principle of counterpressure, the punch is entirely inadequate in cutting a calcareous valve, and to have one cutting edge revolve upon the other as it cuts spends too much force in friction and in overcoming inertia. The shear, however, affords the ideal mechanical advantage.

The valvulotome (Fig. 3) that has been devised consists of two, closed curved, shearing edges, which by compression of the handle approximate each other and accurately override so that the tissue lying between the cutting edges is excised and encased in the instrument. As the force applied to the handle is released, the cutting edges move apart by virtue of a spring concealed in the handle. The distal portion of the instrument is a bluntly pointed pyramid with a cutting edge on its proximal end, which, by telescoping the handle, approximates the opposing cutting edge of the shaft into which it accurately cups. The cutting edges are adjusted to employ the principle of the shear and this contributes to make the instrument a powerful cutting device.

The operative procedure as worked out in the laboratory is as follows:

The heart is exposed by the subperiosteal removal of the fifth rib, from the costochondral articulation laterally about 5 inches. A suture placed in the

apex provides for traction and handling of the heart. A region devoid of coronary vessels, as near the apex as possible, and away from the base of the anterior papillary muscle[1] is selected for the introduction of the valvulotome. Two sutures of silk taking a deep bite of muscle are placed in the area selected for the insertion of the instrument so that the four threads represent on the surface of the heart a square of 1 cm. These are the control sutures and they are of importance in the control of hemorrhage. A small scalpel placed between the control sutures so as to bisect the hypothetical square cuts the ventricular wall in a plane slightly oblique to the surface of the heart. If there is any bleeding, and experience has shown that there need be no bleeding, the control threads which have been crossed are made slightly taut. The valvulotome, after having been filled with salt solution to displace the contained air, is introduced through the incision into the cavity of the left ventricle and is then allowed to open. The cutting edges are introduced into the mitral ring, the position being determined accurately by the index finger of the left hand as it feels the end of the instrument through the invaginated wall of the left auricle. The mitral valve leaflets now lie between the cutting edges and, by telescoping the handle, parts of one or more of them are excised and encased in the instrument which is then removed from the heart. Slight traction upon the control sutures prevents any bleeding as the instrument is withdrawn and the wound is closed with one or two silk sutures (Fig. 4). The control sutures and the apex suture are removed and the heart is replaced in the pericardial cavity. The pericardium is sutured and before completely closing the pleura the lungs are expanded to expel the air from the chest and the wound is sutured in layers.

That this operative procedure is feasible upon dogs has been well demonstrated in the laboratory where in a series of thirty dogs twenty-four survived the operation, almost all of which were given a well marked mitral insufficiency (Fig. 2). Of the six operative fatalities two occurred immediately after making the incision at the base of the anterior papillary muscle preparatory to the insertion of the valvulotome, one was the result of hemorrhage, and three followed the creation of an excessive regurgitation due to the removal of too large a segment from the valve. The tolerance of the heart toward this procedure is evidenced by blood pressure tracings which show only

[1] The literature contains numerous references to the so called vital areas of the heart and they appear to lie in the region of and immediately adjacent to the auriculoventricular ring. To these vital areas our experience adds the region at the base of the anterior papillary muscle and this represents the only area near the apex of the left ventricle that should be avoided.

slight variations with the placing of sutures, the displacement of the heart, the insertion of the valvulotome, and the creation of an insufficiency. The feasibility of the operative procedure is shown further by an operation upon a human case in which a segment of the stenosed mitral valve was actually excised and removed from the heart.

SUMMARY.

1. A study of the fibrosed and often calcareous condition present in the mitral orifice in cases of chronic stenosing rheumatic disease demonstrated that a powerful instrument must be developed if we are to apply surgical relief in the treatment of the disease.

2. An instrument (cardiovalvulotome) is described which actually excises a segment from the mitral orifice and removes this from the blood stream.

3. The efficacy of the instrument has been tested by its use on the stenotic valves of diseased hearts removed at autopsy. Its feasibility has been shown by operations both upon animals and in a single human case.

BIBLIOGRAPHY.

1. Cushing, H., and Branch, J. R. B., Experimental and clinical notes on chronic valvular lesions in the dog and their possible relation to a future surgery of the cardiac valves, *J. Med. Research*, 1907–08, xvii, 471.
2. Haecker, R., Experimentelle Studien zur Pathologie und Chirurgie des Herzens, *Arch. klin. Chir.*, 1907, lxxxiv, 1035.
3. Schepelmann, E., Versuche zur Herzchirurgie, *Arch. klin. Chir.*, 1912, xcvii, 739.
4. Tuffier, T., and Carrel, A., Patching and section of the pulmonary orifice of the heart, *J. Exp. Med.*, 1914, xx, 3.
5. Allen, D. S., and Graham, E. A., Intracardiac surgery—a new method, *J. Am. Med. Assn.*, 1922, lxxix, 1028.
6. Tuffier, T., La chirurgie du coeur, *15th Cong. Soc. Internat. Chir., Paris, 1920*, 1921, 5.
7. Doyen, quoted by Tuffier (6).
8. Cutler, E. C., and Levine, S. A., Cardiotomy and valvulotomy for mitral stenosis. Experimental observations and clinical notes concerning an operated case with recovery, *Boston Med. and Surg. J.*, 1923, clxxxviii, 1023.

EXPLANATION OF PLATES.

PLATE 14.

FIG. 1. Photographs showing mitral stenotic valves. The insets are x-ray films showing calcium deposits in the valves; the insets to the left are of the valves before cutting, those to the right are of the excised fragments.

FIG. 2. Photograph showing mitral valve, Dog 1, 2 months after operation.

PLATE 15.

FIG. 3. Photographs and mechanical drawing of the valvulotome. The cutting edges show the shearing principle. By telescoping the handle the cutting edges override so that the distal portion cups into the shaft. The length of the instrument is 20 cm. and the inside diameter is 1 cm.[2]

FIG. 4. Drawing showing the operative procedure in the dog. The inset shows the distal portion of the valvulotome and the excised segments of the mitral valve.

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[2] The valvulotome is made by Codman and Shurtleff, Inc., of 120 Boylston Street, Boston, Mass., to whom it is a pleasure to express appreciation of their cooperation in the construction of the instrument.

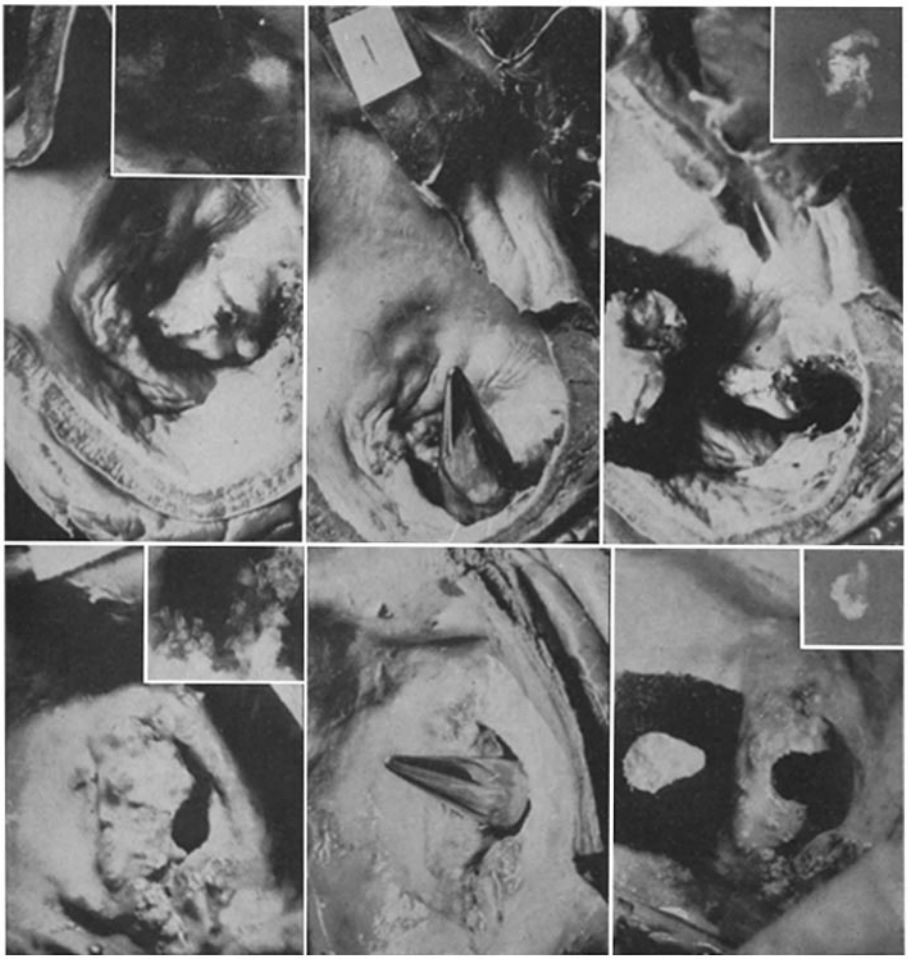

FIG. 1.

FIG. 2.

(Beck and Cutler: Cardiovalvulotome.)

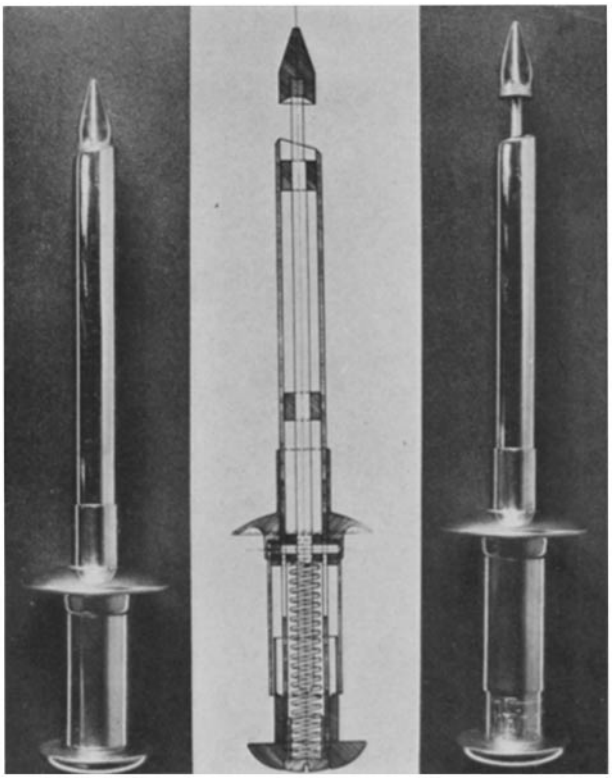

FIG. 3.

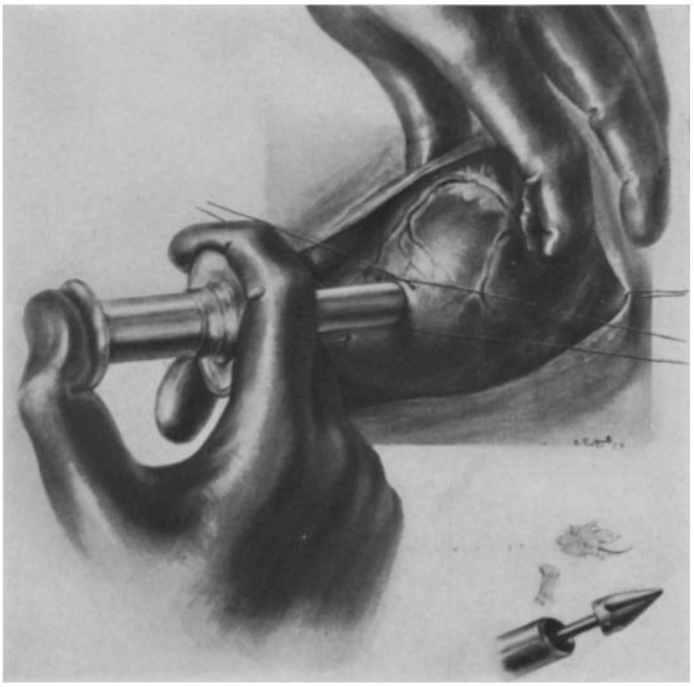

FIG. 4.

(Beck and Cutler: Cardiovalvulotome.)