tions. The possibilities of prophylactic immunizations, using the complement-fixation test to check the progress of the immunization, are obvious. Lastly, the test may be employed as a means of determining the presence or absence of the virus, whether in the natural host, experimentally infected animals, or inoculated tissue cultures. Experiments are in progress on an evaluation of the complement-fixation test, as employed for these purposes.

Received September 25, 1950. P.S.E.B.M., 1950, v75.

A Cannula for Simultaneous Drainage of Both Cavae in Artificial Heart Experiments.* (18234)

SANFORD E. LEEDS. (Introduced by Meyer Friedman)

From the Harold Brunn Institute for Cardiovascular Research, Mount Zion Hospital, San Francisco.

One of the many problems connected with a mechanical heart preparation is that of the cannulation of both the superior and inferior vena cavae. The superior vena cava may be cannulated easily through the azygous vein, which may then be ligated after removal of the cannula [Gibbon(1); Leeds, Gray, and Cook(2)]. The inferior vena cava may be cannulated through the right auricular appendage which is then ligated after removing the cannula [Gibbon(1)]. In order to simplify the cannulation, a single right angle cannula was constructed which permits blood from both the cavae to pass through it and thence flow to the pump. This procedure saves a step in the experiment, and appears to be more satisfactory than having two cannulas. It is certain to drain the entire caval flow and, therefore, should be preferable to the method of Jongbloed(3), who passes a catheter into each cava near the auricle and applies suction to draw the blood from the cavae to the pump. With the new cannula ligated in place no blood from the cavae can enter the right auricle, and it must all be diverted. The right auricle or ventricle may be opened with very little blood loss since only the coronary flow enters the operative site. The latter constitutes about 5 or 6% of the cardiac output [Harrison, Friedman and Resnick(4)].

The purpose of the present communication is to describe a right angle cannula which is passed through the azygous vein and which in one operation permits the drainage of

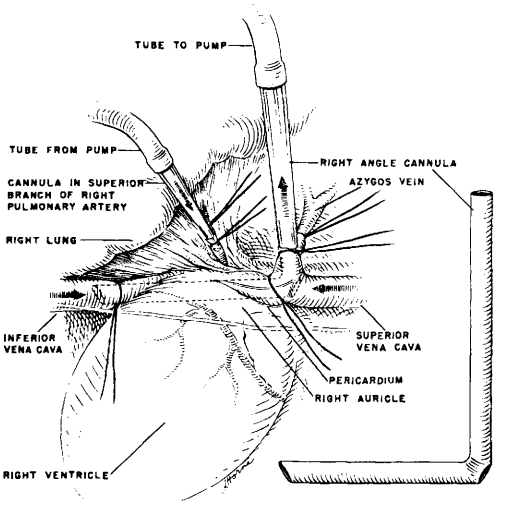

FIG. 1.

Diagram which shows cannula inserted through azygous vein into superior and inferior *vena cavae.* The ligatures prevent any caval blood from entering the right auricle. The cannula which returns the blood from the pump to a branch of the right pulmonary artery is also shown.

* Supported by a grant from the Division of Grants and Fellowships, National Institute of Health, U. S. Public Health Service.

1. Gibbon, John H., Jr., reported at 13th Cong., International Soc. of Surg., New Orleans, October 1949.

2. Leeds, Sanford E., Gray, Norman, and Cook, Orrin S., *Surg., Gyn., and Obst.*, in press.

3. Jongbloed, J., *Surg., Gyn., and Obst.*, 1949, v89, 684.

4. Harrison, T. R., Friedman, B., and Resnick, H., *Arch. Int. Med.*, 1936, v57, 927.

blood from both the cavae. This cannula has been used satisfactorily in more than 25 experiments in dogs in which an extracorporeal shunt was established.

Description of the cannula. The cannula consists of thin-walled (26 gauge) metal tubing of uniform diameter with 2 arms at an angle of 90 degrees. The tube is open at both ends and is also open at the vertex of the angle (Fig. 1). Cannulae of 5/16 inch and 1/4 inch inside diameter were most satisfactory for the large dogs which we used. The larger cannula is used whenever possible. The shorter arm measures 8.0 cm and the end is oblique in order to facilitate insertion into the azygous vein and inferior cava. The longer arm measures 11.5 cm and the end is cut transversely for attachment to rubber tubing. The interior of the cannula is coated with silicone before it is used.

Method of insertion and removal. The azygous vein is prepared for insertion of the cannula by dissecting it free for a distance of 2 or 3 cm from the junction with the superior vena cava. Two silk or cotton ligatures are placed around the azygous vein; the distal one is tied, and the proximal one is tied around the cannula after it is inserted. Prior to insertion of the cannula the pericardium is opened by a longitudinal incision over the superior vena cava and right auricle and a length of narrow umbilical tape is placed around the portion of the auricle which the superior vena cava joins. A second tape is placed around the inferior vena cava just inferior to the pericardial reflection. The tapes are tied after inserting the cannula through the azygous vein into the right auricle and thence into the inferior vena cava. During the passing of the cannula the operator covers the opening at the angle with the tip of his index finger to prevent the escape of blood. The tape ligatures make it impossible for any caval blood to enter the right auricle and the entire flow from both cavae is diverted through the cannula into the pump (Fig. 1).

To remove the cannula at the end of an experiment one cuts the tapes and the ligature around the azygous vein with a scalpel. The cannula is then withdrawn quickly and the azygous vein is ligated near its junction with the cava.

TABLE I. Results of Survival Experiments in Which the Triple-opening Right-angle Cannula Was Used.

Exp. No.	Wt (kg)	Occlusion of cavae (min.)	Total output of pump (liters)	Avg flow (cc/min.)	Avg flow (cc/kg/min.)
1	22	31	17.8	560	25.5
2	21	13	9.6	740	36.2
3	15	26	23.2	890	59.3
4	30	25	12.1	490	16.3
5	28	28	20.6	730	26.1
6	18	32	21.7	680	37.8
7	23	46	41.5	900	39.1
8	14	41	44.8	1090	77.9
9	15	15	14.6	980	65.3
10	12	33	25.8	780	65.0
11	18	42	73.6	1750	97.2
12	18	46	71.0	1540	85.6
13	22	30	46.1	1540	70.0
14	24	21	34.0	1620	67.5
15	17	18	19.8	1100	64.7
16	15	23	16.3	710	47.3
17	29	68	72.4	1064	36.7
18	20	41	48.4	1180	59.0
19	21	34	39.8	1170	55.7
Avg	20.1	32.3	34.4	1027	54.3

Results of experiments. In Table I are summarized the results of 19 experiments in which the entire venous flow of blood was diverted from the cavae for from 13 to 68 minutes followed by survival of the animals for an indefinite period. It is seen that flows as high as 1750 cc per minute passed through the pump. Factors which interfere with the efficiency of the mechanical heart are under study; however, the size of the cannula is undoubtedly adequate to carry the entire cardiac output with ease.

Summary. A single cannula which can be tied in place to divert the entire flow of both the superior and inferior vena cava has been described. This cannula has been useful in experiments in which an extracorporeal pump or artificial heart has been employed.

Received September 20, 1950. P.S.E.B.M., 1950, v75.