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EVALUATION OF INTERNAL MAMMARY ARTERY LIGATION FOR RELIEF OF ANGINA PECTORIS

CHARLES R. BLAIR, ROBERT F. ROTH, AND HAROLD A. ZINTEL

In February 1957 soon after we became aware of the operation of bilateral internal mammary artery ligation for the relief of angina pectoris, studies were begun on dogs in an attempt to contribute information as to the benefit or lack of benefit of this procedure. Articles published in Italian Minerva Medica in 1955 and 1956 presented work by M. Battezzati, A. Tagliaferro, and G. DeMarchi[1, 2] which demonstrated, by dye injection techniques, anastomoses between the internal mammary arteries and the coronary arteries through the pericardiophrenic arteries. They also reported some of their clinical results and concluded that the procedure was beneficial in humans with angina pectoris.

Our studies include acute and long term survivor observations on dogs. By use of the method later described we measured total coronary flow with the aorta unclamped, with the aorta clamped, and with both the aorta and internal mammary arteries clamped in the third intercostal space. By clamping the aorta and at the same time sucking all blood from the left side of the heart, it was postulated that there should be no coronary flow unless there were outside anastomoses to the coronary arteries. If, while the aorta is clamped, the internal mammary arteries are also clamped distal to the origin of the pericardiophrenic artery, one might expect an additional coronary flow if the operation described for relief of angina is actually effective. Further, if there is such an additional flow, can it be eliminated by then clamping the internal mammary arteries proximal to the origin of the pericardiophrenic artery? Measurements were made under all of the above conditions.

Anatomical studies were carried out using an injectable plastic material and radioactive iodinated serum albumin (RISA). We also were able to demonstrate anastomoses connecting coronary and internal mammary vessels but the results are not included in this report.

After some experimentation we decided upon the following method to determine coronary flow which could be measured with or without clamping the internal mammary arteries.

METHOD

Nembutal anesthetized dogs on an automatic breathing apparatus were connected to the Dewall type bubble oxygenator with Sigma motor pump set to produce 60% of normal flow of each dog, i.e. 60 cc./kg.

A femoral vein and a femoral artery were catheterized. Arterial systolic pressures were recorded in all dogs. The mean arterial systolic pressures varied between 100 and 110 mm. Hg. The dogs were heparinized with a dose of 1 mg./kg. injected intravenously before the carotid artery and vena cava catheters were inserted.

The arterial catheter from the pump was placed in the right carotid artery. The venous catheters were placed in the superior and inferior vena cavae. The azygos vein was securely ligated.

After the pump-oxygenator was turned on, a previously prepared 30 cc. Foley bag catheter was introduced through a stab wound in the right ventricle and pushed up the pulmonary artery. A purse-string suture around the catheter prevented bleeding. The balloon was inflated in the post-valvular area. The distal portion of the catheter had previously been plugged and ligated, and holes were cut in the catheter proximal to the balloon. Thus, all blood which returned to the right side of the heart would run off through this catheter. Suction was not used. This gave a measure of coronary circulation and was recorded in cc./min.

A 5 cc. Foley bag catheter, unmodified, was placed on constant suction through a stab wound in the left ventricle. This was used to draw off any blood from the left heart that could possibly find its way into the coronary system. A purse string suture was also placed around this catheter.

The aorta was then doubly clamped above the aortic valve to prevent blood from entering the coronary arteries from the aorta, and after a period of 15 seconds the flow from the right ventricular catheter was measured. For each determination blood was collected over a period of one minute.

The aorta was then unclamped and the heart allowed to have its normal coronary circulation. Multiple repeat measurements were carried out both with the mammary arteries clamped and unclamped.

It is, of course, recognized that the method used does interfere in part with the mammary-coronary anastomotic system since pericardial branches are divided where the pericardium is opened and periaortic branches are occluded when the aorta is clamped. This interference would decrease the possible contributions of these anastomoses.

DISCUSSION

The amount and rate of normal coronary circulation could easily be determined with this setup. In the dogs studied the amount was about 100 cc./min., and the coronary circulation time was approximately 4 seconds.

While working out the method of study, it was soon found that with the dog on the pump-oxygenator bypass, and with the aorta unclamped, there could be withdrawn from the left ventricular catheter anywhere from 30 to 120 cc. of bright red blood per minute. This was considered to be from aortic valve leakage and from return of bronchial circulation. After the aorta was doubly clamped, the left sided catheter return was 5 to 8 cc./min. This might roughly represent the amount of bronchial circulation return to the left side of the heart.

Four successful acute dog experiments were performed. The internal mammary arteries were exposed bilaterally in the third intercostal space so that they could be clamped or unclamped at will.

Spring operated bulldog type clamps were used for this purpose. Multiple determinations were carried out on each dog. Fifteen measurements with the internal mammary arteries unclamped gave a range of 0 to 4 cc./min. volume, with an average of 1 cc. Fourteen measurements with the internal mammary arteries clamped gave a range of 0 to 2 cc./min. volume with an average of a little less than 1 cc. (Table 1).

Thus in acute experiments there was no significant coronary flow

regardless of whether the internal mammary arteries were clamped or unclamped.

In February, 1957, 6 dogs were prepared for long term survivor studies by bilateral extrapleural internal mammary artery ligation in the third intercostal space. Five of these dogs were suitable for study 6 months later.

A total of 39 measurements were performed on these dogs (Table 2). All of the dogs showed a consistent coronary circulation that averaged from 8.2 to 10.5 cc./min. volume with the aorta clamped. The average was 9.6 cc. This amount is approximately 10% of normal coronary flow.

On the last 2 dogs studied several determinations were carried out with the internal mammary arteries temporarily clamped at their origin. This theoretically would eliminate any contribution of mammary-coronary anastomoses. These measurements were alternated with the previously described measurements. It was found that such clamping resulted in a flow of less than 1 cc./min. The measurements unclamped would return to their usual average of 9 to 10 cc. A total of 8 such determinations were made.

Table 1. Results in Dogs, Acute Experiments, With and Without Bilateral Internal Mammary Artery Ligation in the Third Intercostal Space

Four Dogs, 12 to 20 kg.			
PUMP-OXYGENATOR	60 cc./kg. FLOW	MEAN PERFUSION PRESSURE 100-110 mm. Hg	
	CORONARY FLOW CC./MIN.		
	RANGE	MEAN	AVERAGE
Mammary Arteries Clamped, 15 determinations	0-4	1	1.1
Mammary Arteries Unclamped, 14 determinations	0-2	0	0.6

Table 2. Results in Dogs Six Months Post Bilateral Internal Mammary Artery Ligation in Third Intercostal Space

Five Dogs, 12.3 to 16.4 kg. Total of 39 measurements				
PUMP-OXYGENATOR	60 CC./KG. FLOW	PUMP FLOW	MEAN PERFUSION PRESSURE 100-110 MM.	
			CORONARY FLOW CC./MIN.	
DOG	kg.	CC./MIN.	AVERAGE	MEAN
1	13.3	800	9.3	9.5
2	16.4	1000	10.5	9.5
3	14.5	870	10	10
4	13.2	800	10	10
5	12.3	740	8.2	9
All dogs	13.9	830	9.6	9.5

Note: In acute experiments with internal mammary arteries clamped at their origin the coronary flow averaged less than 1 cc./min.

CONCLUSION

It is thus suggestive that bilateral internal mammary artery ligation in the third intercostal space in dogs does lead to a significant contribution of arterial blood from the extracardiac mammary circulation to the coronary circulation.

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OBSERVATIONS ON CONTROLLED CARDIAC ASYSTOLE IN INTACT DOGS*

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Although elective cardiac arrest with potassium ions and acetylcholine[1] has been accepted as an aid to open intracardiac surgery, it is desirable to evaluate the effects of this procedure in the absence of a complicating thoracotomy and cardiotomy. A method has been developed which permits observation of the mechanisms of arrest and recovery in an intact animal while circulation is maintained by means of a pump-oxygenator. This report is concerned with the details of the method and experimental results obtained.

There were two general objectives to this investigation. First, we wished to determine if it was feasible to produce elective cessation of cardiac activity in intact animals under controlled conditions with survival of the animal and without evidence of cardiac injury. Second, we have tried to evaluate the action of a variety of cardioplegic substances in the absence of complicating thoracotomy and cardiotomy.

METHOD

Adult mongrel dogs weighing in excess of 12.5 kg. were anesthetized with intravenous nembutal (15 mg./kg.). The right external jugular vein, left common carotid artery, and the common femoral arteries and veins were exposed. Heparin was administered intravenously in a dose of 1.5 mg./kg. Plastic catheters were introduced into the right external jugular and right common femoral veins and were advanced so that the tip of the superior catheter was at the level of the third intercostal space while the tip of the inferior catheter was at the level of the fourth intercostal space. These

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