Coronary Arterial Perfusion in Puppies

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An operation has been developed here at the University of Michigan Medical Center for the correction of an anamalous left coronary artery originating from the pulmonary artery in newborn infants. The surgical repair requires prolonged total aortic occlusion. In order to prevent myocardial hypoxia and its sequelae during this period, coronary arterial perfusion is desirable.

A polyethylene cannula, suitable for infant coronary vessels, has been developed in conjunction with Sarns, Incorporated. This study was designed to investigate the effectiveness of coronary arterial perfusion in puppies utilizing this cannula.

MATERIAL AND METHODS

The coronary cannula, constructed of polyethylene, is approximately 31 cm in length. It has an internal diameter of 1.68 mm and an external diameter of 2.41 mm. A bulb of fixed circumference is located at the tip to permit proper placement of the cannula in the coronary ostium and to prevent retrograde leakage during coronary perfusion. On the opposite end of the coronary cannula is a female luer-lok connector.

Six puppies, weighing between 3.2 kg and 9.0 kg were studied. All of the puppies were anesthetized with intravenous sodium pentobarbital. A cuffed endotracheal tube was inserted and respirations were maintained with a Harvard respirator utilizing room air. The right femoral artery and vein were cannulated with polyethylene catheters for continuous monitoring of systemic arterial and central venous pressures.

A transverse thoracotomy was performed through the fourth intercostal space. Heparin (3 mg/kg) was administered. Venous drainage was provided by a single large cannula placed in the right atrium. The left femoral artery was cannulated for systemic arterial perfusion. A sump catheter was inserted in the left ventricle for decompression.

Cardiopulmonary bypass was carried out in each dog by means of a roller pump and a disposable bubble oxygenator primed with heparinized whole blood. Normothermic perfusion at flow rates between 77-127 cc/kg/min (mean: 99 cc/kg/min) maintained normal systemic arterial pressures in all of the animals.

In-line arterial oxygen tensions were monitored by the Bentley oxygen analyzer and its accuracy verified by an Instrumentation Laboratory blood gas analyzer. Intramyocardial oxygen tensions were determined by a Transydine pO_2 micro-electrode. Calibration was performed with 100% Nitrogen (0% Oxygen) and room air (pO_2 determined with the I.L. gas analyzer).

Coronary perfusion flow rates were determined in the study by measuring the stroke volume output of the

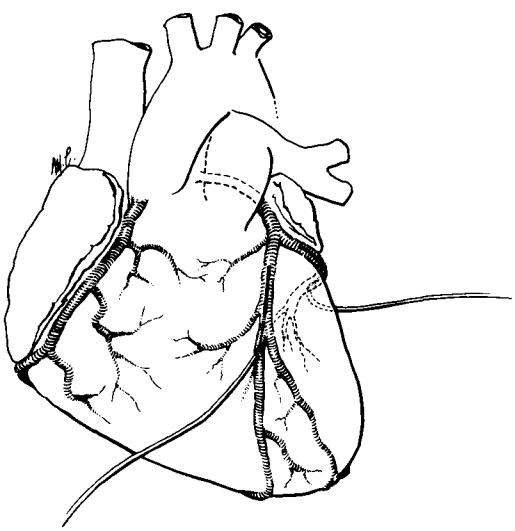

Figure 1

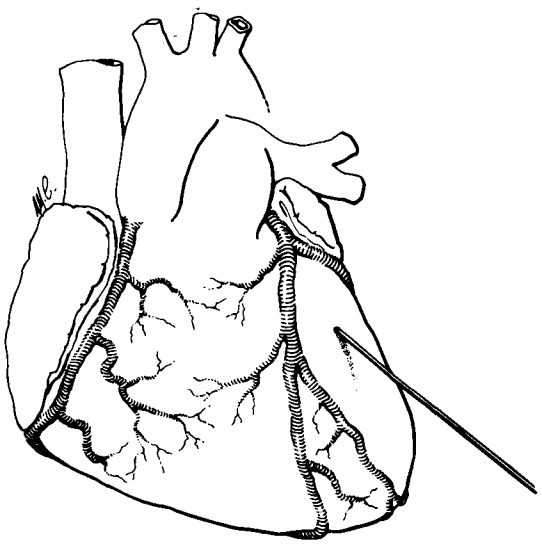

Figure 2

coronary perfusion pump and multiplying this value by the number of revolutions per minute. The coronary perfusion pressure was monitored by an aneroid manometer located above the reservoir.

The six puppies were divided into two groups of three animals each. In Group I, the distal left anterior descending and circumflex coronary arteries were cannulated with polyethylene catheters for continuous pressure monitoring prior to and during coronary artery perfusion (Figure 1). The aorta was crossclamped and a proximal aortotomy was performed. The coronary perfusion cannula was inserted into the left coronary ostium and sutured in place. The pressure gradient across the coronary perfusion line was considered to be the difference between the coronary perfusion reservoir pressure and the intracoronary pressure.

In Group II, intramyocardial oxygen tensions, utilizing the Transydine electrode, were recorded prior to and during perfusion of the left coronary artery. Intramyocardial oxygen tensions were determined in the anterior left ventricular wall between the anterior descending and circumflex coronary arteries (Figure 2).

TABLE I. THE RESULTS OF THE GROUP I STUDY

CORONARY PERFUSION FLOW RATES	RESERVOIR PRESSURES	CORONARY PRESSURES
22 cc. / min. *	164 mm. Hg. *	85 mm. Hg. *

* MEAN VALUES FOR THREE DOGS.

RESULTS

Group I. The coronary pressures during total cardiopulmonary bypass, prior to extracorporeal coronary arterial perfusion, ranged from 85-110 Hg (mean: 97 mm Hg). The coronary pressures during coronary arterial perfusion ranged from 55-100 mm Hg (mean: 88 mm Hg).

The pressure gradient across the coronary perfusion line ranged from 55-110 mm Hg (mean: 79 mm Hg) (Table I.). Coronary perfusion flows during this period ranged from 15-32 cc/min (mean: 22 cc/min).

Group II. Myocardial oxygen tensions ranged from 51-296 mm Hg (mean: 147 mm Hg) during total heart-lung bypass prior to total aortic occlusion and coronary arterial perfusion. After two to three minutes of aortic occlusion, myocardial pO_2's ranged from 17-150 mm Hg (mean: 67 mm Hg). After coronary arterial perfusion commenced, myocardial oxygen tensions ranged from 215-230 mm Hg (mean: 223 mm Hg) (Table II.). Coronary flow rates during this period were 30-40 cc/min with a mean value of 36 cc/min.

Systemic arterial oxygen tensions averaged 480 mm Hg (range: 110-595 mm Hg) for both groups during the entire period of total cardiopulmonary bypass.

DISCUSSION

The coronary cannula was flexible enough to be placed through the aortotomy and inserted into the left coronary ostium. It permitted flow rates capable of maintaining the physiologic coronary pressures and adequate myocardial oxygenation. In the six puppies studied, gross trauma of the intima of the left coronary ostium by the coronary cannula was not visualized.

TABLE II. THE RESULTS OF THE GROUP II STUDY

	TOTAL HEART-LUNG BYPASS	TOTAL AORTIC OCCLUSION	CORONARY ARTERIAL PERFUSION
MYOCARDIAL pO_2	147 mm. Hg. *	67 mm. Hg. *	223 mm. Hg. *
SYSTEMIC ARTERIAL pO_2	383 mm. Hg. *	270 mm. Hg. *	420 mm. Hg. *

* MEAN VALUES FOR THREE DOGS

CONCLUSIONS OF THE STUDY

I. CORONARY ARTERY PRESSURES WERE MAINTAINED AT PHYSIOLOGIC LEVELS DURING CORONARY ARTERY PERFUSION.

II. SATISFACTORY TISSUE OXYGENATION WAS MAINTAINED DURING CORONARY ARTERY PERFUSION.

III. CORONARY ARTERIAL PERFUSION WITH THE SARNS CORONARY CANNULA IS FEASIBLE IN INFANTS.

There was no significant difference in the coronary pressures before and during extracorporeal coronary perfusion ($p>0.02$).

The study demonstrated that myocardial oxygen tensions increased during coronary artery perfusion.

Coronary perfusion flows averaged 14 cc/min higher in Group II than in Group I. This may be explained in two ways:

A. In Group I, the distal left anterior descending and distal circumflex coronary arteries were ligated after insertion of the pressure catheters. This would decrease the area of coronary vascular beds in these regions, increasing resistance to flow. Flow rates required to maintain a constant coronary perfusion pressure (indicated by the aneroid manometer on the coronary reservoir) would be reduced.

B. Puppies in Group II were 24% heavier than those puppies in Group I. Flow rates/kg body weight in Group II were 42.5% greater compared to Group I.

Our study has shown that the left coronary artery of puppies can be perfused adequately with this cannula and may be applicable to infants undergoing prolonged aortic occlusion during surgical correction.

SUMMARY

Six infant puppies underwent extracorporeal coronary arterial perfusion utilizing a cannula developed for perfusion of coronary arteries in human infants. Using this cannula, flow rates necessary for maintenance of adequate coronary pressures and myocardial oxygen tensions were achieved.