Fibreoptic studies of the aortic valve in dogs

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The study describes a method for visualisation of the aortic valve in the intact animal using a non-obstructive endoscopic system. Clearing of blood from the field of vision is achieved by the rapid injection of saline during a period of asystole.

Attempts have been made since 1913 to visualise intracardiac structures endoscopically with only modest success. Clearly, the main problem is how to replace the blood with a transparent medium for a sufficient length of time in order to permit observation and photographic recording. Three distinct methods have been used to clear the blood from intracardiac structures: (a) direct contact between the endoscope and the structure under examination, (b) displacement of blood by a transparent chamber between the lens system and the object, (c) displacement of blood by a clear fluid injected under pressure.

Before the report of Carlens and Silander in 1961, endoscopy had been performed only on the surgically exposed heart. Carlens and Silander used an endoscope equipped with an inflatable balloon over the lens system to inspect the interior of the right atrium in the intact animal. In 1964 Silander reported the clinical use of this method in 7 patients. Using similar methods, Gamble and Innis (1967) extended the procedure to inspect the aortic valve and the interior of the left ventricle in dogs. The obstruction to the circulation caused by the inflated balloon is a limiting factor to the usefulness of this method.

Several investigators have used clear fluid injected under pressure to enable visualisation of intracardiac and aortic structures. Only Pinet et al. (1966) used this method in the intact animal and they emphasised the difficulties and traumatic nature of the method. There have been no further reports on the use of this technique over the past 10 years.

In this paper an account is given of studies of the aortic valve in dogs using a 3 mm fibreoptic endoscope introduced via a carotid arteriotomy. The important and perhaps crucial variation in technique has been significantly to reduce cardiac output before and during the rapid injection of saline above the aortic root. This has permitted clear observation of the aortic valve with an unmodified endoscope and has also permitted observations to be made at varying distances from the valve. Examples of still photographs are illustrated in the Fig.

Method

Dogs weighing 1134 to 1588 g were selected for study and were anaesthetised using morphine intravenously (3 mg/kg) and an α-chloralose/urethane mixture (urethane 1000 mg/kg α-chloralose 100 mg/kg). This method of anaesthesia usually resulted in a bradycardia of between 50 and 60 beats a minute. On occasion supplemental doses of propranolol were administered to induce bradycardia. A cuffed endotracheal tube was inserted enabling the intrabronchial pressure to be varied. Acute rise in the intrabronchial pressure to between 40 and 60 cm of water has two effects: (a) the heart and aorta are squeezed and partially emptied, (b) the venous return is virtually stopped resulting in a drastic reduction in cardiac output. Nordenstrom (1960) has documented the use of this technique both in dogs and humans in order to increase the relative concentration of injected radiographic contrast media. Vagal stimulation was also used to induce a period of asystole. In practice the animals were often refractory to vagal stimulation, and in the later experiments this technique was discontinued. A 3 mm Olympus fibreoptic endoscope was introduced into the aorta via an arteriotomy in a carotid artery. A No. 9 French gauge NIH catheter was introduced via an arteriotomy in a femoral artery and its tip placed immediately above the aortic valve.

By means of raising the intrabronchial pressure
Fig. Four views of the aortic valve as seen through a 3 mm fibreoptic scope. The hatching is the result of the arrangement of the fibre bundles.
with or without vagal stimulation, asystole could usually be induced. Ninety ml normal saline were injected through the NIH catheter at a flow rate of 40 ml/s. The selection of such a large volume and flow rate was arbitrary and was close to the maximum attainable by the injection device used. Still photographs using Kodachrome II (ASA 80) or cine film using Kodak Ektachrome (ASA 60) were obtained during the transient period of clearing. The period of asystole could last from 5 to 15 seconds under normal circumstances. The dogs tolerated the procedure well and only 1 death was directly attributable to the examination out of some 8 experiments performed. In this instance the myocardium was perforated by the catheter and the animal succumbed in cardiac tamponade. The earlier experiments were somewhat compromised by the inadequacy of the standard light source, but the acquisition of an Olympus CLX high intensity light source has given greater latitude in camera work. Single plane fluoroscopy was used for catheter positioning and this meant that directional work with the endoscope was necessarily haphazard.

Discussion

The experiments described indicate that it is possible to achieve clear visualisation of the aortic valve with a non-obstructing endoscopic system provided that the cardiac output can be reduced drastically or stopped temporarily and that a rapid bolus of transparent fluid can be injected. It is important to have a significant reduction in heart rate even before acute methods to reduce cardiac output are applied. Experience showed that the tachycardia induced for example by pentobarbitone, resulted in problems with reducing the cardiac output. An increase in the intrabronchial pressure proved to be a very effective method of inducing asystole in the dog. Direct vagal stimulation was variable in its effect and was not as satisfactory as had been hoped. The standard endoscopic light source permitted only long film exposures and limited the distance from which one could observe the valve. The acquisition of a high intensity light source has enabled shorter exposure times and faster cine shutter speeds to be used as well as facilitating actual observation of the valve.

The present research has concentrated on the aortic valve in order to refine the techniques and equipment on an easily recognisable structure that could be readily localised.

References


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