Long-Term Observation of Atrial and Ventricular Rates in the Unanesthetized Dog with Complete Atrioventricular Block

M. Boucher, C. Dubray, and P. Duchene-Marullaz

Laboratoire de Pharmacologie Médicale, INSERM U.195, Faculté de Médecine, F-63001 Clermont-Ferrand Cédex, France

Abstract. The evolution of atrial and ventricular rates was studied in unanesthetized dogs with complete A-V block over a three-year period. During the first 40 days after A-V block, atrial rate far exceeded the sinus rate recorded before surgery, but had fallen progressively back to this level by the 41st day, and remained there until the end of the three-year period. Ventricular rate had settled down to a plateau by the 31st day. These findings explain certain differences among previously reported results, and have led us to use such animals for drug studies only after the beginning of the third month after creation of the complete A-V block.

Key words: Unanesthetized dogs - Complete A-V Block - Atrial rate - Ventricular rate.

INTRODUCTION

In the anesthetized dog, the creation of a complete atrioventricular (A-V) block brings about immediate hemodynamic modifications arising out of the drop in the ventricular rate thus produced. The cardiac output, coronary flow and mean arterial pressure are markedly reduced, while the stroke volume is considerably increased (Eyster and Swarthout, 1920; Starzl et al., 1955; Willman et al., 1961; Brockman, 1965). However, the time-course of these modifications had not yet been well-studied. Starzl and Gaertner (1955), who repeatedly anesthetized their animals with pentobarbital in order to facilitate measurement, noted, over four observations spread over 20 weeks, a progressive return of the mean arterial pressure and of the coronary flow to preoperative values. They made no explicit mention of evolution of heart rate, though their use of pentobarbital would have made any such measurements dubious, since this anesthetic is known to have a cardioaccelerator action (Nash et al., 1956; Barlow and Knott, 1964; Cox, 1972; Manders and Vatner, 1976). The present paper reports a study of the time-course of the atrial and ventricular rates in the unanesthetized dog with complete A-V block over a three-year observation period.

METHODS

Fifty-two mongrel dogs of either sex weighing between 12 and 26 kg were used. Complete A-V block was produced by crushing the bundle of His with forceps through the open right atrium during temporary occlusion of the venae cavae (Fredericq's technique, 1904-1911) as modified by Jourdan and Froment (1937). Cardiac electrical activity was recorded from the three standard leads (DI, DII, DIII) with an ECG recorder (Cardiopan III T Massiot Philips, France) in unanesthetized dogs trained to remain calmly on a table. Under these conditions, spontaneous atrial and ventricular rates (averaged over a period of 30 s) were measured from the day after A-V dissociation. In order to have a sufficient number of values (n > 8) throughout the whole observation period, this latter was deliberately restricted to three years (1095 days). Nevertheless, several animals were followed for much longer, one in particular for nearly 10 years. Over these three years, 21 observation periods were arbitrarily delimited. This procedure was established a posteriori for most of the animals, which, along with premature deaths, explains the variability of the number of dogs in the different observation periods thus chosen (see Fig.1).

The results were expressed as means ± S.E.M. Statistical analysis of the data was performed, first by one-way analysis of variance followed by Student's t-test in nonpaired series in order to compare the rate values with the first period values (Fig.1), then by one-way analysis of variance starting with the values of the last period of observation in order to determine the extent of the stable plateaus (range of F not significant).

RESULTS

Under our experimental conditions, the sinus rate observed in the unanesthetized dogs prior to A-V dissociation was 82 ± 6 beats/min. During the first 10 days after A-V block, the atrial rate recorded in these dogs significantly (P < 0.001) exceeded the sinus rate, reaching 148 ± 3 beats/min (Fig.1 and 2). Atrial rate fell thereafter and from the 11th day onwards became significantly different (P < 0.01) from that observed during the first 10 days after surgery. From the 41st day, in spite of marked variations, the atrial rate became stable and leveled off statistically to a plateau which persisted throughout the remainder of the three-year observation period. Between the 41st and the 50th days, the atrial rate was thus 108 ± 10 beats/min and between the 911th and 1095th days 80 ± 10 beats/min.

Under the same conditions, the ventricular rate, which was 49 ± 2 beats/min during the first 10 days after surgery, fell significantly to 39 ± 2 beats/min (P < 0.001) between the 76th and the
DISCUSSION

The mean heart rate of the unanesthetized normal dog at rest is usually between 75 and 110 beats/min (see O'Rourke and Bishop, 1971; Chassaing et al., 1979). Comparable values were recorded in the present study before creation of the A-V block. After surgery, the atrial rate rose to 148 ± 3 beats/min, i.e. by about 80%. This relative atrial tachycardia diminished progressively thereafter and the atrial rate had fallen back to initial sinus values by the 41st day and remained at this level throughout the rest of the three-year observation period. Few published data are available concerning the values of the atrial rate of the unanesthetized dog with complete A-V block. For periods one to four weeks after creation of an A-V block, Hurwitz (1971) reports values between 120 and 200 beats/min and Reynolds and Di Salvo (1978) report a mean value of 143 ± 23 beats/min. At four to six weeks after destruction of the bundle of His, Robinson et al. (1973) observed a mean rate of 125 ± 10 beats/min, which is somewhat lower than that reported by Reynolds and Di Salvo earlier after creation of the A-V block. These reported data are consistent with our own findings.

Mean ventricular rate was 49 ± 2 beats/min during the first 10 days after surgery. It fell thereafter and leveled off from the 31st day. These results are also close to previously reported values. At one to four weeks after creation of the A-V block, Hurwitz (1971) reports values between 26 and 54 beats/min and Reynolds and Di Salvo (1978) a mean value of 55 ± 13 beats/min. After four to six weeks, Robinson et al. (1973) observed a value of 37 ± 3 beats/min.

Such modifications of rate cannot be attributed to post-operative shock consequent to thoracotomy since other surgical operations such as placing of flow probes on the aorta or on a coronary artery or implantation of atrial or ventricular electrodes, do not bring about significant variations of heart rate in dogs used to the recording conditions. It would be much more reasonable to suppose that the newly-created hemodynamic conditions initially lower vagal tone in the atria and bring into play an adrenergic mediation in the ventricles. It is difficult to say whether the progressive lowering of both atrial and ventricular rates during the post-operative period is due to progressive correction of these hemodynamic modifications or to an adaptation of barosensitive reflexes. Work is under way to seek an answer to this question.

The findings reported here do provide an explanation for some of the differences observed among previously reported results, and must clearly be taken into consideration in drug studies involving unanesthetized dogs with complete A-V block. Accordingly, we have used such animals only after the beginning of the third month after creation of the complete A-V block (Boucher and Duchêne-Marullaz, 1978-1980; Boucher et al., 1979 a-b).