His bundle electrogram in children

Statistical correlation of the atrioventricular conduction times in children with their age and heart rate

Nigel Roberts and Peter Olley

From the Department of Cardiology, The Hospital for Sick Children, Toronto 101, Ontario, Canada

Between July 1970 and October 1971, 89 children with congenital heart disease but normal PR intervals in the standard 12-lead electrocardiogram had His bundle potentials recorded during routine cardiac catheterization. There was a significant increase in the HV interval with age ($P < 0.001$) whereas there was no significant alteration in the P'H interval with age.

The heart rate did not correlate significantly with either the change in P'H or HV intervals.

In 1969 Scherlag *et al.* described a catheter technique for recording His bundle activity in man.

Roberts and Olley (1971, 1972) have reported their earlier work on His bundle potential recording in children demonstrating the effect of age on the HV interval, and Brodsky *et al.* (1971) have reported their findings in 35 children in which they inferred that the P'H interval increased with age.

In this paper we report on a larger number of children and demonstrate the statistical validity of our finding that while the HV interval increases with age the P'H interval does not show any constant relation to age.

Subjects and methods

Eighty-nine children with normal PR intervals in the 12-lead electrocardiogram underwent cardiac catheterization and His bundle potential recordings.

Seventeen children had a haemodynamically normal heart; 15 had pulmonary valve stenosis; 13 had a ventricular septal defect, 11 had the tetralogy of Fallot; 9 had a secundum atrial septal defect; and the remaining 24 children had a variety of cardiovascular defects consisting of aortic stenosis, supra-aortic, valvular, and sub-valvular, atrial septal defect (primum), atrial septal defect and pulmonary valve stenosis, cardiomyopathy, Ebstein's anomaly, endocardial fibro-elastosis, mitral regurgitation, persistent ductus arteriosus, pulmonary hypertension, supra-aortic

pulmonary stenosis, and D-transposition of the great arteries. Their ages ranged between 2 weeks and 17 years. No child was on any drug therapy other than CM₃ (pethidine, chlorpromazine, promethazine), the normal Hospital for Sick Children premedication (Smith, Rowe, and Vlad, 1958). All the electrophysiological data were recorded before angiography was performed.

The His bundle potentials were obtained by positioning the electrode catheter at the site of the His bundle and recording through a DR8 Electronics for Medicine recorder with a low level filter of 12 Hertz and a high level filter of 2,000 Hertz. The recordings were obtained on photographic paper at 100 mm/sec.

The intervals, P'H and HV (Fig. 1), were measured from the intracardiac electrogram as previously described (Roberts and Olley, 1971 1972).

Results

The P'H and HV intervals of the 89 patients are tabulated with the age and heart rate in Tables 1 and 2.

1) Multiple regression (Draper and Smith, 1966). The multiple regressions on the P'H interval with age and heart rate and the multiple regression on the HV interval with the age and heart rate were calculated.

The P'H interval failed to correlate with either age or heart rate, but the HV interval showed a highly significant correlation with age ($P < 0.001$). There was, however, no significant correlation with the heart rate.

FIG 1 External lead II electrocardiogram and internal electrocardiogram (His bundle electrogram), P'H and HV intervals.

2) **Partial correlation** (Spiegel, 1961) When the age and heart rate were independently kept constant by statistical methods, we were still unable to show a significant correlation between the P'H interval and either parameter.

However, when the HV interval was correlated with the age holding the heart rate constant, there was a highly significant correlation ($P<0.001$), but when holding the age constant there was no significant correlation between the HV interval and heart rate.

Fig. 2 illustrates the correlation of HV interval and age and the expected HV interval at a given age. The standard error of the mean is included.

Discussion

The PR interval as a whole is known to prolong with age (Alimurung and Massell, 1956). Its two components, the P'H and HV intervals, can respond separately under various physiological and pharmacological stimuli (Lister *et al.*, 1965; Rosen *et al.*, 1969, 1970; Damato *et al.*, 1970; Roberts, Olley, and Kidd, 1971).

Several factors may alter the P'H interval which reflects conduction between the sino-

TABLE 1 P'H interval (msec)

	< 1	1-2	3-4	5-6	7-8	9+1 yr
100	110	100	100	80	95	
70	85	85	125	80	85	
80	115	85	110	85	80	
85	85	110	100	80	110	
90	105	60	80	99	100	
65	115	75	65	100	70	
85	80	60	75	80	105	
95	65	115	105	60	100	
90	60	90	76	100	94	
90	100	80	100	80	85	
70	115		70	80	95	
75			80	100	70	
			85	115	90	
			80	73	100	
			100	80	90	
				110	90	
				100	70	
				65	100	
				90		
				75		
				94		
				90		
range						
65-100	60-115	60-115	65-125	60-115	70-105	

atrial node to the bundle of His: it is prolonged by rapid atrial rates, carotid sinus stimulation, and digitalis, and it is shortened by atropine and isoprenaline. The HV interval represents further propagation of the cardiac impulse from the His bundle through the ventricular Purkinje system to reach the ventricular myocardium. The conduction velocity may reach 4000 mm/sec in this part

TABLE 2 HV interval (msec)

	< 1	1-2	3-4	5-6	7-8	9+ yr
	20	20	30	30	30	40
	30	25	25	30	30	25
	30	20	35	30	20	35
	25	20	25	35	40	35
	25	30	35	30	34	20
	20	25	30	25	25	25
	25	30	25	25	30	30
	20	30	30	40	20	35
	25	26	25	25	30	40
	20	25	20	30	35	36
	25	20		30	20	30
	25			35	30	40
				35	35	40
				25	24	40
				25	30	30
					33	25
					35	40
					40	40
					30	40
					30	
					20	
					40	
Mean	24.2	24.7	28.0	30.3	30.0	34.0
Standard error of mean	0.7	1.4	2.1	1.8	1.4	1.3

FIG. 2 The change in HV interval with age.

of the system. In healthy adults the HV interval is minimally affected by heart rate or parasympathetic tone.

We have shown that in children the HV interval increases with age independently of the heart rate, but we were unable to demonstrate a consistent relation between age and the P-H interval. This gradual increase in the HV interval may be explained by increased length of the conduction pathway, by a progressive slowing of conduction velocity, or by a combination of both. We are unaware of any experimental evidence suggesting that conduction velocity decreases with age nor have we been able to find measurements of the intraventricular conduction system in children. However, the simplest explanation that the HV interval increases as the conduction pathway lengthens with growth seems most acceptable.

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Requests for reprints to Dr. Nigel Roberts, Department of Cardiology, The Hospital for Sick Children, 555 University Avenue, Toronto 101, Ontario, Canada.