

A STUDY OF ELECTROGRAMS RECORDED FROM THE CONUS ARTERIOSUS OF AN ELASMOBRANCH HEART*

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Electrograms of fish have been briefly described by Kisch (1948, 1949) and Oets (1950). Both authors reported an additional excursion (B wave) on the ST segment, corresponding to contraction of the conus arteriosus. This communication gives a more detailed account of this event and of its relationship to the behaviour of the conus.

Port Jackson sharks (*Heterodontus portusjacksoni*) were anaesthetized by intravenous injection of Tricaine (MS222, Sandoz) (4–6 mg/lb body wt.) and mounted ventral side uppermost in a stainless steel tank containing constantly circulating sea-water. The air-conditioned room was maintained at a temperature of $17 \pm 1^\circ\text{C}$. The heart was exposed within the pericardium. Conal electrograms were recorded by means of a unipolar silver electrode to which was attached a 1.5-cm length of cotton thread moistened with elasmobranch Ringer, and were displayed on an oscilloscope.

Results

Conal electrograms (positivity upwards) are illustrated in Figures 1 and 2. Wave complexes were identified by comparing them with those of ventricular electrograms recorded simultaneously. These wave forms varied considerably from animal to animal, in some preparations being entirely monophasic (either positive or negative) but generally being polyphasic to various extents. However, in all electrograms, the P, QRS, and T complexes were readily identified. In addition, conal electrograms exhibited a large excursion in the ST segment, corresponding to conal contraction. This is designated as the conal depolarization complex (B_d). In some preparations (Fig. 1) a prominent wave occurred between the T wave of one cardiac cycle and the P wave of the next. This corresponded to conal diastole and accordingly, is designated as the conal repolarization complex (B_r). Why a B_r wave was not always present is not clear. Generally, the B_d complex occurred before the T complex, but in three preparations the two wave forms occurred simultaneously, or at least, overlapped. Figure 2 is of such a preparation. Here the B_d and T complexes overlapped in electrograms recorded ≥ 3.5 mm from the conus-ventricular (CV) junction (Fig. 2).

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The electrograms presented in Figure 2 were recorded at a series of distances distal to the CV junction. It is clear from the figure that the conal depolarization complex occurs later in the ST segment with increasing distance from the CV junction; its onset is marked by a dot. The onset of the "intrinsic deflection" probably represents the wave of excitation passing beneath the recording electrode (Hoffman and Cranefield 1960). A plot of the times of arrival of excitation with position on the conus did not reveal a specific pattern of excitation spread. Excitation appeared to emanate at the CV junction and travel diffusely to the rostral end.

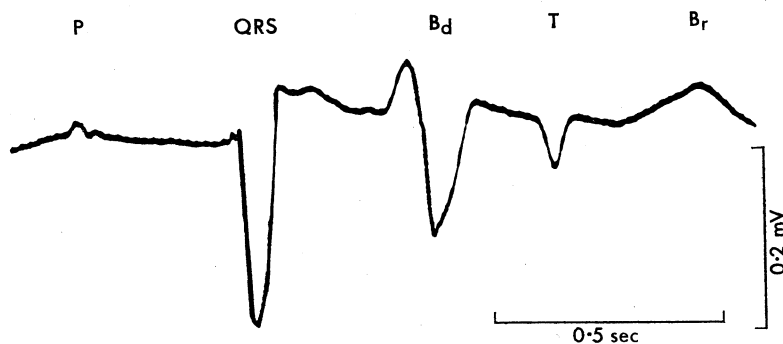


Fig. 1.—Conal electrogram in which the conal repolarization (B_r) wave was prominent.

By calculating the time delay between the intrinsic deflections of two conal electrograms recorded at a measured distance apart, an approximate conduction velocity of 2–4 cm/sec was determined. Similarly (using the intrinsic deflection of the QRS complex), the conduction velocity of surface excitation in the ventricle was determined (40–100 cm/sec). For a more accurate value, it is necessary to determine the fibre length between the two points of recording. However, the approximate values given above serve to indicate the relative magnitudes of conduction velocity between the ventricle and conus.

The PR value represents the time for excitation to travel from the atrium to the point of recording on the ventricle. PR values of ventricular electrograms recorded on the immediate proximal side of the CV junction were 50–160 msec shorter than those of conal electrograms immediately distal to the CV junction. This indicates that there is a delay in excitation spread across the CV junction.

Discussion

The conus arteriosus of the Port Jackson shark is a relatively thick-walled, muscular, barrel-shaped chamber containing three tiers of semilunar valves. The results of this investigation suggest that the electromechanical properties of conal tissue enable the conus to function according to the hypothesis proposed by Satchell and Jones (1967).

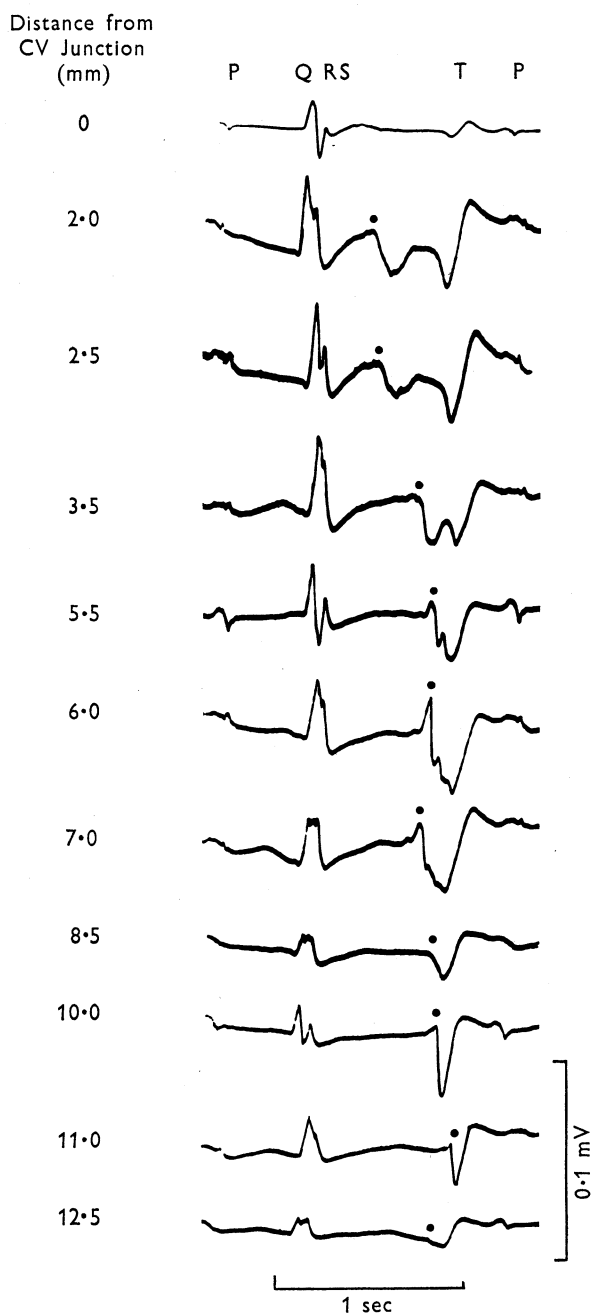


Fig. 2.—Conal electrograms recorded at various distances from the conus-ventricular (CV) junction. The conus in this preparation was 13 mm long. The dot indicates the beginning of the slow "intrinsic deflection" of the B_d complex.

Excitation spreads relatively quickly over the ventricle, which contracts synchronously. There is a delay at the CV junction, after which excitation travels diffusely forward over the conus. This delay prevents conal systole from occurring too soon after ventricular systole and so enables the ventricle to expel its contents with a minimum of resistance. The spread of excitation in the conus is extremely slow (compare values for heart muscle by Schaefer and Trautwein 1949; Brendel, Raule, and Trautwein 1950; Curtis and Travis 1951), causing the conus to contract slowly in a peristaltic wave which begins at the CV junction and moves forward. Since the B_d wave occurs late in the ST segment, the lower conus must contract during late ventricular systole. Similarly, the short time delay between the B_r and T waves in the upper conus indicates that this portion must contract just before, or as, the ventricle relaxes. By means of blood pressure and flow recordings, Satchell and Jones (1967) showed that the lower conal valves close first, before the end of ventricular systole, and that the upper conal valves close at the end of conal systole. They proposed the hypothesis that the conus serves to postpone the closure of the upper valves until the negative intrapericardial pressure, caused by ventricular ejection, has decreased to a lower value. The sequence of events indicated by conal electrograms is in accord with this hypothesis. The low conduction velocity of conal muscle accounts for this.

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