

## On the Effect of the Second and Third Ligatures of Stannius on the Frog Heart

The explanations of the effects of the three ligatures of STANNIUS, which have been generally accepted, are the following:

*First ligature* round the junction between sinus venosus and atria causes stoppage of both auricles and ventricle because the pacemaker, i.e. the sinus venosus, is excluded; the motor impulse originating from the sinus can no longer pass the sino-auricular boundary. The stoppage may be permanent or temporary. In the last case the automatic power develops sufficiently in the posterior parts to cause a re-establishment of the beating, be it in slower rhythm than that of the sinus (STANNIUS<sup>1</sup>).

*Second ligature* at the auriculo-ventricular groove has as its effect that the ventricle again begins beating. This is caused by mechanical stimulation of the nerve-elements in the atrio-ventricular boundary, since loosening the ligature is followed again by a standstill (GOLTZ)<sup>2</sup>.

*Third ligature* round the ventricle at a ring one third of its length from the point of the heart causes the stoppage of the ligated-off tip and the continued beating of the rest of the ventricle. The conclusion is that the tip of the heart misses automatic power (BERNSTEIN<sup>3</sup>), which is in agreement with the absence of nerve-elements (HABERLANDT<sup>4</sup>; cf. also BIEDERMANN<sup>5</sup>).

In the literature there are no data on the frequency with which after the third ligature the rest of the ventricle continues pulsation. We have been struck many times by the fact that this frequency can be raised considerably, even to double the value with which the ventricle was beating before the ligature. We tried to explain this increase in frequency by a lowering of the threshold for automatism as being due to the stress of the ventricular wall caused by constriction of its contents, which had been enclosed by the precedent ligatures. As is generally known, restoration of endocardial pressure re-establishes pulsation and increase of that pressure raises the frequency (LUDWIG and THIRY<sup>6</sup> via bloodpressure, LUDWIG and LUCHSINGER<sup>7</sup> artificially via a cannula). If our explanation were the correct one, then it could also be applied to the effect of the second ligature (A/V-groove).

Indeed the following findings confirm this supposition:

(1) Increase in stretching of the wall of the heart results within certain limits in an increase in frequency of the pulsations (table I) and in a drop of the threshold for stimulation by induction-shocks (table II). It is indifferent whether the stretching is increased by fixing the heart to the lever of the registering apparatus (A) and raising its load, or by making ligatures after the first STANNIUS ligature (B).

(2) A second ligature round the tip of the heart even just under the "serre fine" (the clip which connects the heart via a thread to the recorder), can be as effective as one round the auriculo-ventricular boundary, also as

<sup>1</sup> H. STANNIUS, Müller's Arch. Anat., Physiol. und med. Wiss. 85 (1852).

<sup>2</sup> Fr. GOLTZ, Arch. pathol. Anat. 21, 201 (1861).

<sup>3</sup> I. BERNSTEIN, Centralbl. med. Wiss., 14. Jahrgang, 385 (1876).

<sup>4</sup> L. HABERLANDT, Z. Biol. 67, 89 (1916).

<sup>5</sup> W. BIEDERMANN, Sitzgsber. Akad. Wiss. Wien, Math.-naturwiss. Kl., Abt. I, 68, 20 (1884).

<sup>6</sup> J. M. LUDWIG and THIRY, Wiener med. Sitzgsber. (1864).

<sup>7</sup> J. M. LUDWIG and B. LUCHSINGER, Pflügers Arch. 25, 227 (1881).

Table I

Beat frequency of ventricle/5 min

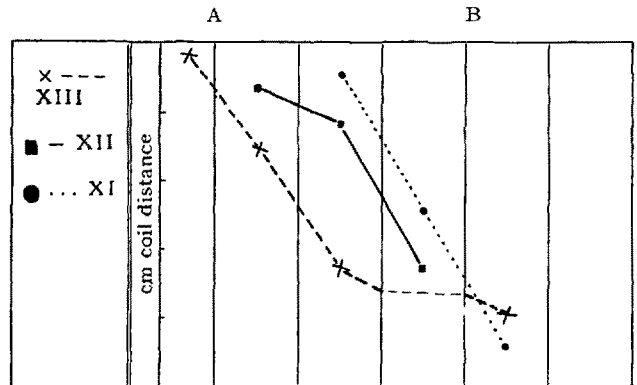
Heart number	A		B			
	Without ligatures	With ligatures successively round	S/A junction	1/8 from ventricle tip	A/V groove	1/8 from ventricle tip
I	152	195	120		170	
III	185	219	0	90		115
IV			111	128	137	

regards the automatic power coming into operation. The atria take part in this pulsating, since the A/V boundary is not blocked by a constriction.

(3) Loss of blood is unfavourable for the above-named effects.

Table II

Threshold for heart stimulation by induction shocks



(4) Other mechanical stimuli (unconstricted ligatures, putting on the "serre fine", contact of electrodes) have only a temporary effect and cause mostly a decrease of frequency.

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### Zusammenfassung

Nach GOLTZ soll die zweite STANNIUS-Ligatur als mechanischer Dauerreiz die Wiederherstellung des Ventrikelpulses bewirken.

Unsere Versuche zeigten, daß Dehnung des Herzmuskels die Reizschwelle für Induktionsschläge herabsetzt. Sie kann ferner sowohl zur Steigerung der Herzschlagfrequenz wie zum Durchbruch des vorher unterschweligen Automatievermögens des Ventrikels führen. Es ist gleich, ob die Dehnung durch Belastung (Anspannung des Herzens am Registrierhebel) verursacht wird oder durch Anlegen von Ligaturen, welche durch Druck auf das in Atria und Ventrikel eingeschlossene Blut die Muskulatur dehnen.

Andere mechanische Dauerreize gaben nur vorübergehende Effekte und öfters Herabsetzung der Frequenz.