Novel histological evidence of atrio-ventricular (AV) node in Atlantic salmon (*Salmo salar* L.)

Introduction

The mammalian cardiac conduction system consists of three main parts: (1) the sino-atrial node (pacemaker), (2) the atrio-ventricular node (AV node) and (3) the His- Purkinje system. The heartbeat starts in the autonomous pacemaker cells (SA node), is delayed at the AV node and propagates to rest of the heart by the His- Purkinje system. So far, the AV node has not been identified in a teleost histologically. Here we present the novel histological evidence of the AV node in Atlantic salmon (*Salmo salar* L.).

Materials & Methods

Several hearts were sampled from apparently healthy Atlantic salmon (*Salmo salar* L.) and rainbow trout (*Onchorynchus mykiss*). Serial histological sections of complete formalin-fixed hearts were stained with haematoxylin and eosin (HE). In addition, special stains such as Cresyl violet (for Nissel substance) and combination of Cresyl violet og Luxol fast blue were used.

Results

The novel atrio-ventricular node (AV node) was identified in Atlantic salmon and rainbow trout. The AV node lies endo-, myocardially and/or in the AV valve with ocassional focal melanisation of few ganglion cells.

The AV node comprises (1) a few to several ganglion cells (12-22 µm in size) with granular cytoplasm, (2) nerve bundles with oval elongated wavy appearing nuclei with pointed ends, (3) modified cardiomyocytes that appeared more lightly stained and (4) loose connective tissue.

Conclusion

This finding suggests that teleost fish (Atlantic salmon & rainbow trout) harbour the ‘AV node’ as identified in mammals.

The salmon heart has a tiny button of specialized cells known as the ‘AV node’ at the centre of the heart which controls the heart rate by slowing electrical impulses coming from the pacemaker cells.

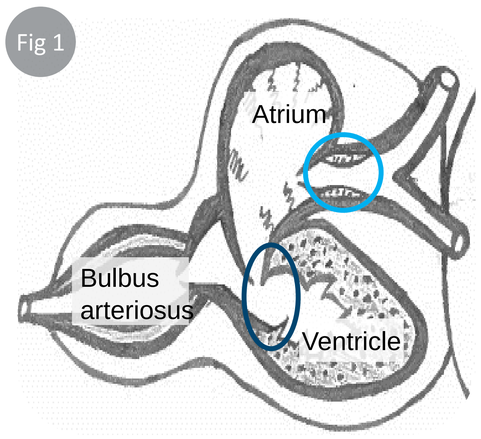

Figure 1. Schematic view of Atlantic salmon heart. Area for sino-atrial pacemaker (within the light blue circle) and atrio-ventricular node location (within the dark blue oval) were shown.

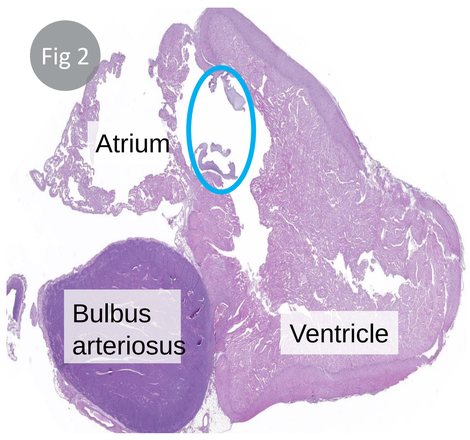

Figure 2. Low power view of H&E stained Atlantic salmon heart showing atrium, ventricle and bulbus arteriosus. Location of atrio-ventricular node (AV node) was shown within the blue oval.

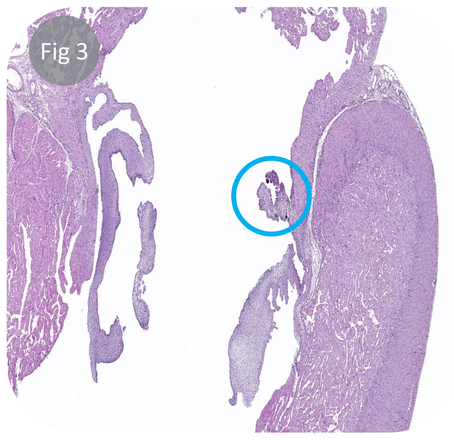

Figure 3. Micrograph shows flaps of atrio-ventricular valve harboring cluster of ganglion cells at AV valve (within light blue circle).

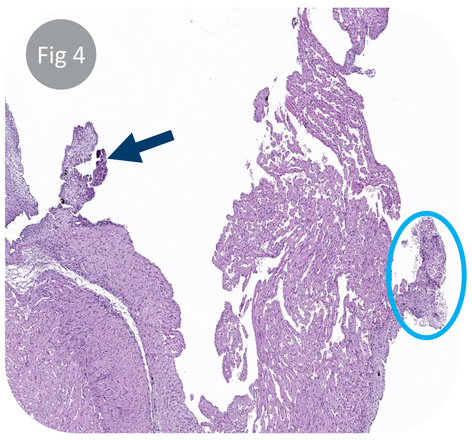

Figure 4. The AV node and pacemaker area were shown together in one individual fish heart. The pacemaker tissue was shown within the light blue circle while the AV node lies endo/, myocardially within the AV valve (dark blue arrow).

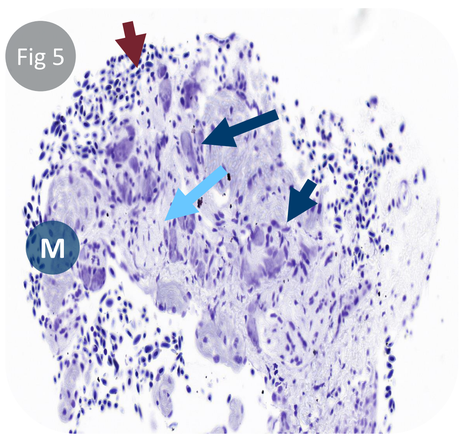

Figure 5. High power view of pacemaker area (Fig. 4 within blue oval) stained with Cresyl violet luxol staining showing the pacemaker tissue with ganglion cells (dark blue arrows), nerve (light blue arrow), red blood cells (red arrow) and modified cardiomyocytes (M).

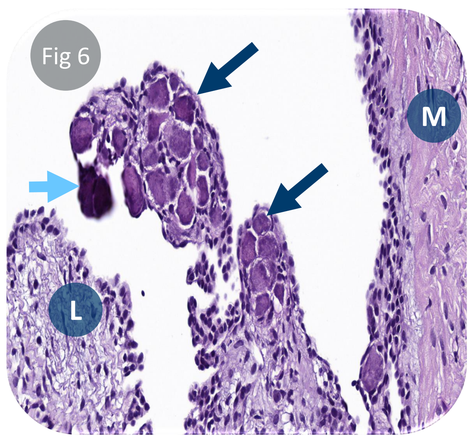

Figure 6. The AV node comprises ganglion cells (dark blue arrow), melanized ganglion cells (light blue arrow), loose connective tissue (L) and modified cardiomyocytes (M).

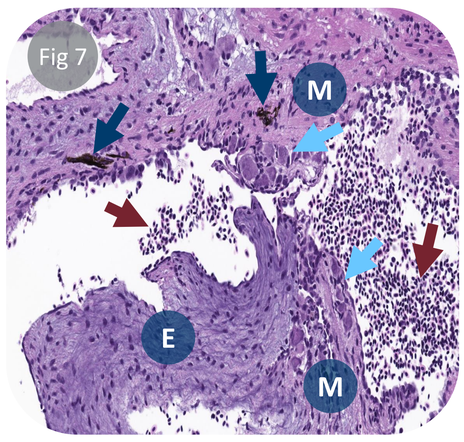

Figure 7. The AV node in rainbow trout showing ganglion cells (light blue arrow), modified cardiomyocytes (M), melanin (dark blue arrow), elastic tissue (E) and red blood cells (red arrow).

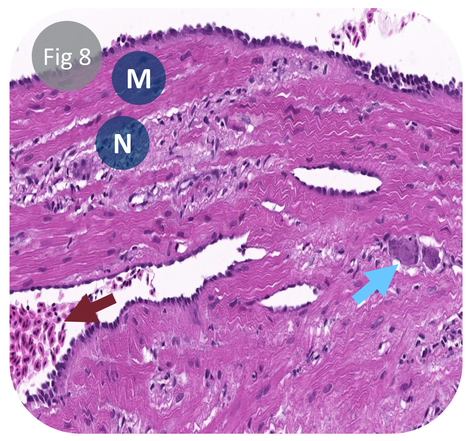

Figure 8. High power view of AV node in rainbow trout showing ganglion cells (light blue arrow), modified cardiomyocytes (M), lightly stained nerves (N) and red blood cells (red arrow).

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