Structure change of a molluscan smooth muscle during catch contraction

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Introduction

Molluscan smooth muscles have a property of maintaining tension for a very long time with very little expenditure of energy (catch). Comparing between the small-angle X-ray diffraction patterns from the anterior byssus retractor muscle of *Mytilus edulis* (ABRM) in the early stage of catch and in the active state during phasic contraction [1], it was found that although the tension was lower in the catch state than in the active state, the axial periods of the thick filament reflections were larger in the catch state than in the active state [2]. It was confirmed in this work that the thick filaments were really elongated with transition of the ABRM from the active to the catch by comparing small angle X-ray diffraction patterns in the active state with those in the catch state which was produced just after recording the pattern of the active state.

Experimental Results and Discussions

Small-angle X-ray diffraction patterns were recorded on imaging plates using a point focusing camera with a camera-length of 170 cm. The ABRM was isometrically contracted by stimulation with acetylcholine (Ach). In order to detect spacing changes without missing a slight change much less than 0.1 %, high tensions were produced using a strong Ach solution (10^{-3} M) [3]. The pattern in the active state was recorded at a plateau of tension during stimulation with Ach solution which was flowed through the sample cell. The specimen was successively changed into the catch state by replacing the Ach solution with artificial sea water, and the X-ray pattern in the catch state was recorded 8 min after the replacement of the solutions when the ABRM was almost completely changed into the catch state. Then, the catch tension was relaxed by serotonin solution (2.5×10^{-5} M) to record the pattern in the resting state.

The intensities of the reflections from the thick and thin filaments were integrated radially. After subtraction of the background intensity, the profiles of the integrated intensity were compared between the resting, active, and catch states. The speed of relaxation of tension after replacing of Ach solution with artificial sea water depends on samples. If the amount of relaxation of tension 8 min after the replacement of the solutions is less than 25 % of the tension just before the replacement of the solutions, the axial periods of thick filament reflections are more elongated in the catch state than in the active state, contrary to the axial periods of the thin filament reflections which are decreased in the catch state (Table 1).

Table 1: Change in the axial periods of the meridional thick filament reflections and the thin filament layer line reflections compared with those in the resting state.

	Thick filament		Thin Filament	
	145 A	73	59 A	51
Active	0.25 %	0.25	0.76 %	1.09
Catch	0.34	0.28	0.59	0.49

Probably the thin filaments in the catch state play a role to tie the thick filaments by strong association between the myosin head and actin, and the tension is held by the thick filaments. The parts of thin filaments where myosin heads are not tied return to the structure of the resting state which is less extensible than the structure in the active state. Because the tension is transmitted to dense bodies, and the connective tissues by such thin filaments through the dense bodies joined to the cell membrane [4 & 5], the thick filaments are stretched by transition from the active state to the catch state in compensation for shrinkage of those thin filaments.

If the relaxation of tension is faster, the extension of the thick filaments in the catch state is probably cancelled out, and undetectable 8 min after washing of Ach.

References

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