Ontogenic Differentiation of Pig Atrial and Ventricular Myosin

I. SYROVÝ

Institute of Physiology, Czechoslovak Academy of Sciences, Vídeňská 1083, 142 20 Prague, Czechoslovakia

Abstract. Myosin was isolated from pig atrial and ventricular myocardium during postnatal development and Ca^{2+}-ATPase was determined and myosin light chains were analysed by electrophoresis in sodium dodecylsulfate polyacrylamide gel. During ontogenesis ATPase activity of ventricular myosin remains virtually unchanged, whereas that of atrial myosin increases. The patterns of myosin light chains of atrial and ventricular myosin differ from each other, but the individual pattern remains unchanged during the development.

Key words: Myosin ATPase activity — Atrial myocardium — Ventricular myocardium — Myosin light chains — Postnatal ontogeny

Introduction

Atrial and ventricular myosin are two distinct proteins. The activity of Ca^{2+}-activated atrial myosin ATPase has shown to be higher than that of ventricular myosin ATPase in the same animal species. In addition to the differences in ATPase activities, the atrial and the ventricular myosin differ in both their heavy and light subunits (see Syrový 1987). Also the atrial muscle contracts approximately twice as rapidly as the ventricular muscle (Korecky and Michael 1974; Urthaler et al. 1975).

The aim of our study was to investigate how atrial and ventricular myosin are influenced by development, i.e. what is the response of the contractile proteins to changing functional requirements. The properties of the ventricular myosin during postnatal ontogenic development have been extensively studied, whereas information on the atrial myosin during the development is scarce.

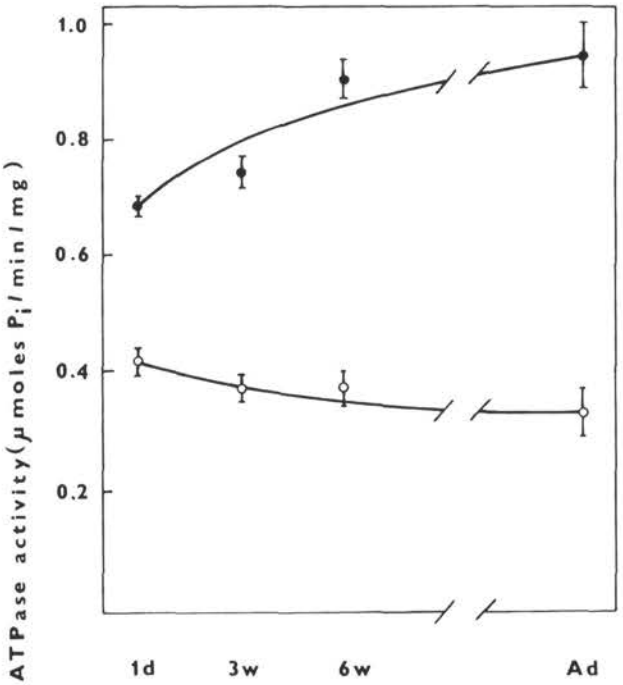

Fig. 1. Activity of Ca^{2+}-ATPase of pig cardiac muscles. Each value represents the mean ± S.D. of three experiments. Open circles: ventricular myosin; filled circles: atrial myosin.

Materials and Methods

Myosin was prepared from the left atria and left ventricles of 1-day-old, 3-week-old, 6-week-old and adult pigs (80 kg). The myosin preparations were pooled to obtain 2—4 g of tissue for each age category. Myocardial tissue from adult pig was first finely cut and mixed, a representative tissue sample was then used for analyses. Myosin was prepared as described elsewhere (Syrový and Gutmann 1977) with 2 mmol/l of β-mercaptoethanol. Ca^{2+}-activated ATPase was determined in a medium containing 0.05 mol/l Tris-HCl, pH 7.5, 10 mmol/l $CaCl_2$, 0.025 mol/l KCl, 5 mmol/l ATP, and 0.3 mg protein/ml. The temperature of the medium was 26 °C. Polyacrylamide gel electrophoresis of myosin was carried out using the tris -glycine system (Laemli 1970).

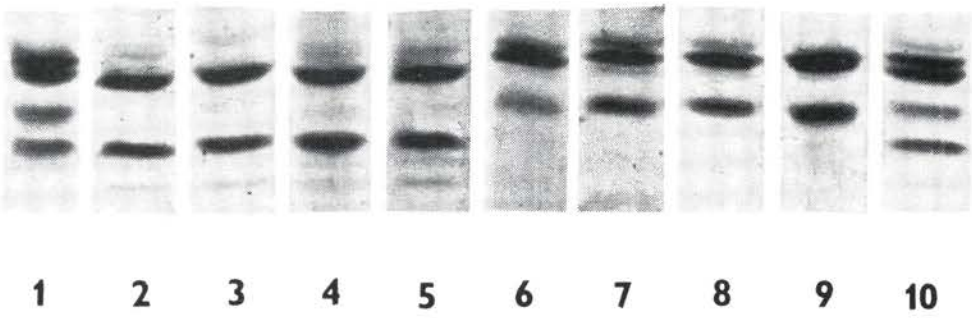

Fig. 2. Electrophoretic fractionation of light chains of ventricular and atrial myosin of the pig in 12.5 % polyacrylamide. 2—5, ventricular myosin from 1-day-old, 3-week-old, 6-week-old and adult pig; 6—9, atrial myosin from 1-day-old, 3-week-old, 6-week-old and adult pig; 1 and 10, coelectrophoresis of atrial and ventricular myosin from 1-day-old and adult pig, respectively. 2—9, 60 μg; 1 and 10, 90 μg.

Results and Discussion

Fig. 1 shows the activities of Ca^{2+}-ATPase of atrial and ventricular myosin during development. The activity of atrial myosin ATPase increases during the postnatal development, that of ventricular myosin ATPase does not change significantly. The activity ratio of atrial to ventricular myosin ATPase was 1.65 for 1-day-old animals and 2.85 for adult pig.

Fig. 2 illustrates the electrophoretic pattern of myosin light chains. Light chains of atrial myosin clearly differ from those of ventricular myosin. The pattern of light chains does not change during the development; the atrial myosin of young pigs, however, has one additional band.

We could show that the pattern of myosin light chains remains almost without change during the postnatal development of the pig, whereas the activity of atrial myosin ATPase reveals a certain dynamics. The function of myosin light chains remains unclear; nevertheless, they do not seem necessary for myosin ATPase activity. Whatever the function of the myosin light chains our results suggest that it is not substantially affected during the postnatal development.

The activity of the ventricular myosin ATPase does practically not change during the development. This is in agreement with the results of Lompre et al. (1981) who reported a predominance of the V_3 isoform of myosin with low myosin ATPase in the ventricular myocardium of developing pigs. The difference between atrial and ventricular myosin ATPase increases during the development; this mainly goes on the account of an increased activity of the

atrial myosin ATPase, suggesting some alteration of myosin heavy chains. It was repeatedly shown by immunohistochemical techniques that two isomyosins containing heavy chains α and heavy chains β coexist in the atria of adult bovine and human heart. The β form is present especially in specific regions of the atrial tissue (Gorza et al. 1982). Our results obtained for myosin from atrial tissue as a whole may not be valid for specific regions of atrial tissue.

The increase of atrial myosin ATPase during development can be explained by a possible decrease of the proportion of myosin heavy chains β with a lower ATPase activity. A developmental transition of myosin isotypes has already been demostrated in bovine atrium (Cummins and Lambert 1986). However, no data are available to check whether postnatal and adult age atrial and ventricular myosin α and β heavy chains are identical. In this respect, the demostration of the presence of myosin α and β heavy chains in the atria during development would be of great value; however, PP_i electrophoresis which is very usefull in separating native ventricular isomyosins does not separate atria isomyosins (Chizzonite et al. 1984).

The higher activity of the atrial myosin Ca^{2+}-ATPase probably accounts for the higher speed of shortening of the atrial muscle. Our observation of an age-dependent increase in the activity of pig atrial myosin ATPase suggests an increase in the muscle contraction speed with age. One can only speculate on the mechanical parameters of atria during development. It may well be that the work load of both parts of the heart does not increase in parallel during development. No data are available on changes in size, shape and thickness of the atria during development; changes of these parameters may influence the mechanics and secondarily the biochemistry of muscle contraction.

References

Chizzonite R. A. Everett A. W., Prior G., Zak R. (1984): Comparison of myosin heavy chains in atria and ventricles from hyperthyroid, hypothyroid and euthyroid rabbits. J. Biol. Chem. **259,** 15564—15571

Cummins P., Lambert S. J. (1986): Myosin transitions in the bovine and human heart. A developmental and anatomical study of heavy and light chain subunits in the atrium and ventricle. Circ. Res. **58,** 846—858

Gorza L., Sartore S., Schiaffino S. (1982): Myosin types and fiber types in cardiac muscle. II. Atrial myocardium. J. Cell Biol. **95,** 838—845

Korecky B., Michael L. H. (1974): Regional differences in contractions of mammalian hearts. In: *Recent Advances in Studies on Cardiac Structure and Metabolism,* (Ed. N. S. Dhalla), vol 4, pp. 77—87, University Park Press, Baltimore, vol 4, pp. 77—87

Laemli U. K. (1970): Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature **227,** 680—685

Lompre A. M., Mercadier J. J., Wisnewsky C., Bouveret P., Pantaloni C., d'Albis A., Schwartz K. (1981): Species- and age-dependent changes in the relative amounts of cardiac myosin isoenzymes in mammals. Develop. Biol. **84,** 286—290

Syrový I. (1987): Isoforms of contractile proteins. Progr. Biophys. Mol. Biol. **49,** 1—27

Syrový I., Gutmann E. (1977): Differentiation of myosin in soleus and extensor digitorum longus muscle in different animal species during development. Pflügers Arch. **369,** 85—89

Urthaler F., Walker A. A., Hefner L. L., James T. N. (1975): Comparison of contractile performance of canine atrial and ventricular muscles. Circ. Res. **37,** 762—771

Final version accepted August 5, 1988