ANALYSIS OF SYNAPTONEMAL COMPLEXES IN BULLS AND RAMS, CARRIERS OF XY/XX CHIMERISM

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ABSTRACT: The aim of this study was to investigate synaptonemal complexes in the bulls and rams originated from heterozygotic twins. We diagnosed dissociation of sex bivalents in the early stage of pachytene. Tissue samples used in this study were obtained from testes after castration of bulls and rams, carriers of the XY/XX chimerism. The analysis of 106 spermatocytes from two chimeric bulls and 175 spermatocytes from three chimeric rams was performed under the light microscope. The results obtained for chimeric animals and animals characterized by the normal karyotype were then compared. We found that the level of early dissociation of X-Y bivalent in chimeric bulls ranged from 2.0% to 5.6% (in the normal bulls – 3.1%). Furthermore, in the chimeric rams, frequency of the early dissociation was higher and ranged from 11.1% to 19.0% (in the normal rams – 3.4%). The early dissociation of sex bivalent could possibly be the cause of the lower fertility in males originating from dizygotic twinning.

INTRODUCTION

The correctness of meiosis and in consequence, of spermatogenesis is essential to animal breeding, reproduction, and development of progeny generations.

One of the best methods for evaluation of chromosomal behaviour during meiosis is the analysis of protein structures appearing along homologous chromosomes (synaptonemal complexes) in pachytene.

Analysis of synaptonemal complexes has been used for estimation of pairing and segregation of the sex chromosomes in the male meiosis in several mammalian species (Gustavsson et al., 1983; Świszcz and Gustavsson, 1991; Villagomez, 1993; Dai et al., 1994; Slota, 1998).

The aim of the present study was to investigate synaptonemal complexes in the bulls and rams originated from heterozygotic twins.

MATERIAL AND METHODS

Tissue specimens used in this study were obtained from fragments of testis taken after castration from two bulls (A, B), three rams (E, F, G), all carriers of the XY/XX chimerism and two bulls (C, D), three rams (H, I, J) with normal karyotype.

Synaptonemal complexes analysis was carried out with the surface spreading technique (Counce and Meyer, 1973). The preparations were analyzed under the light microscope.

RESULTS

We analysed synaptonemal complexes in 206 spermatocyte cells from two chimeric bulls (60,XY/60,XX), and two bulls with normal karyotype (60,XY) (Tab. 1). In several cells we observed dissociation of the sex bivalents in the early stage of pachytene (Fig. 1). The level of early dissociation in the chimeric bulls ranged from 2.0% to 5.6% (in the bulls with normal karyotype – 3.1%).

<table>
<thead>
<tr>
<th>Bull</th>
<th>Karyotype</th>
<th>Number of spermatocytes</th>
<th>Number of X-Y bivalents</th>
<th>Number of early dissociation of X-Y bivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>60,XY/60,XX</td>
<td>50</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>60,XY/60,XX</td>
<td>56</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>60,XY</td>
<td>50</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>60,XY</td>
<td>50</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>206</td>
<td>199</td>
<td>7</td>
</tr>
</tbody>
</table>

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II. Results of the analysis of the synaptonemal complexes in rams

<table>
<thead>
<tr>
<th>Ram</th>
<th>Karyotype</th>
<th>Number of spermatoocytes</th>
<th>Number of X-Y bivalents</th>
<th>Early dissociation X-Y bivalent</th>
<th>X-X bivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>54,XY/54,XX</td>
<td>75</td>
<td>65</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>F</td>
<td>54,XY/54,XX</td>
<td>50</td>
<td>42</td>
<td>8</td>
<td>–</td>
</tr>
<tr>
<td>G</td>
<td>54,XY/54,XX</td>
<td>50</td>
<td>45</td>
<td>5</td>
<td>–</td>
</tr>
<tr>
<td>H</td>
<td>54,XY</td>
<td>50</td>
<td>49</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>I</td>
<td>54,XY</td>
<td>50</td>
<td>48</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>J</td>
<td>54,XY</td>
<td>50</td>
<td>49</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>325</td>
<td>298</td>
<td>26</td>
<td>1</td>
</tr>
</tbody>
</table>

DISCUSSION

Synaptonemal complexes are DNA-associated protein structures responsible for the pairing of homologous chromosomes during zygotene and pachytene stages of meiotic prophase I (Świtosiński, 1995).

Behavior of the X-Y synaptonemal complex can be easily recognized on the background of sex chromosome morphology and pairing. Each substage of pachytene: early, mid and late displays different morphology of X-Y bivalent (Villagomez, 1993). It was shown that the appearance of X-Y bivalent is a useful tool for substaging of pachytene in cattle (Dollin et al., 1989) and sheep (Dai et al., 1994). The three essential substages are classified as follows: early pachytene – axes of X and Y chromosomes are not braided and the chromosomes are partly synapsed; mid pachytene – axes of sex chromosomes become braided and pairing can proceed beyond the pseudautosomal region, alternatively additional pairing/association of free ends may occur; late
pachytene – sex chromosomes become more braided or tangled and excrescences appear along axes (Świński and Stranzinger, 1998).

According to the morphology of the autosomal bivalents we found that the early dissociation of the sex bivalent took place in the mid pachytene stage.

In bulls and rams with normal karyotype the level of early dissociation of sex bivalent is about 3.6% (Świński et al., 1991) and 3.4% (Dai et al., 1994), respectively. These findings are in good agreement with our present results: dissociation of sex bivalent in bulls – 3.1% and in rams – 3.4%. However the level of early dissociation of X-Y in chimeric bulls observed by Świński et al. (1991) was almost three times higher, than frequency of early dissociation diagnosed in our experiment. Furthermore, we observed also the difference between frequency of early dissociation of the sex bivalent in chimeric bulls and rams. The mean values ranged from 3.8% to 15.1% respectively.

Dissociation of the X–Y chromosome bivalent in diakinesis-metaphase I in mice may be responsible for some loss of spermatogenic cells (Krzanowska, 1989). The investigations performed in our laboratory showed the influence of chromosomal chimerism on the decrease of semen parameters of the bulls (Rejduch et al., 1998). On the other hand, Szatkowska and Świński (1996) did not observe any impact of chromosomal chimerism on reproductive traits in rams.

In the mammals, changes in structure of chromosomes lead to pairing configurations other than correctly paired bivalents. Investigation of specific abnormalities of pairing process allows us to predict that the decrease of fertility in the carriers of various karyotype changes, due to the production of unbalanced gametes. Observation of the pairing chromosomes, by the study of the synaptosomal complexes, is an important diagnostic approach in searching for causes of decrease in fertility in domestic animals.

REFERENCES


