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Spontaneous canine transmissible venereal tumor: association between different phenotypes and the insertion LINE-1/c-myc


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Tumor venéreo transmissível canino espontâneo: associação entre diferentes fenótipos e a inserção LINE-1/c-myc

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Summary

Objective: this study aimed to evaluate the LINE-1 transposon inserted in c-myc gene as a specific genetic alteration in cells of spontaneous canine Transmissible Venereal Tumor (TVT) with either lymphocytoid or plasmacytoid phenotypes. Methods: tumoral biopsies from 35 dogs were collected by puncture or exfoliation. Polymerase Chain Reaction (PCR) was carried out with primers myc.s and LINE.A, specific to the LINE-1 segment to detect the presence of LINE-1/c-myc molecular marker. Results: sequence alignment of DNA samples from lymphocytoid and plasmacytoid TVT cells did not show polymorphisms, and the comparison with sequences from the GenBank identified them as a LINE-1/c-myc rearrangement. Conclusions: considering the aggressive nature of the plasmacytoid phenotype, there is no apparent relation between LINE-1/c-myc and the malignancy of TVT. Further studies are needed to establish molecular differences associated with the aggressiveness of the various phenotypes of canine TVT.

Key words: dogs, oncogenes, Polymerase Chain Reaction, transposition elements.

Resumen

Objetivo: este estudio tuvo como objetivo evaluar la expresión del trasposón LINE-1 insertado en el oncogén c-myc como una alteración genética específica en células de Tumor Venéreo Transmisible canino espontáneo con fenotipos

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Introduction

Transmissible Venereal Tumor (TVT) is a spontaneous naturally occurring neoplasia of round cells with lymphocytoid and plasmacytoid phenotypes, frequently observed in dogs of the Botucatu region in the state of São Paulo, Brazil (Amaral et al., 2007). As a rule, it shows no predilection for breed, sex, or age and can be transmitted by transplant of viable tumor cells and between animals through copulation, licking, biting, and scratching, whenever there is a loss of mucosa or skin integrity (Cohen, 1985; Das and Das, 2000; Brandão et al., 2002; Amaral et al., 2004; Nak et al., 2005; Amaral et al., 2007; Lefebvre et al., 2007).

TVT cells are genetically complex, exhibiting great differences between different areas across the world. The normal diploid assembly of the domestic dog cell has 78 chromosomes. All autosomes show acrocentric morphology, with the X chromosome being the largest submetacentric and the Y chromosome the smallest. On the other hand, cytogenetic studies on TVT cells showed wide deviation in the karyotype chromosome number, which exhibits between 57 and 59 chromosomes including several with submetacentric morphology, suggesting the occurrence of rearrangements. These rearrangements may have resulted from balanced fusions and not from the gain or loss of genetic material (Cohen, 1985; Vonholdt and Ostrander, 2006; Murgia et al., 2006; Vázquez-Mota et al., 2008).

Prominent among the known TVT molecular alterations is the rearrangement of the protooncogene c-myc, resulting from the insertion of a repetitive DNA segment of 1.5 Kb belonging to the family of gene transposition elements known as LINE (Long Interspersed Nuclear Element), which do not occur in normal dog cells (Katzir et al., 1985; Katzir et al., 1987; Amariglio et al., 1991; Choi et al., 1999; Chu et al., 2001; Choi et al., 2002; Vonholdt and Ostrander, 2006; Murgia et al., 2006).

Although rearrangement of the LINE-1/c-myc sequence supports the hypothesis that all the cells of this tumor originate from a single tumoral cell...
(Vonholdt and Ostrander, 2006; Murgia et al., 2006), it has recently been demonstrated that gene mutations can be acquired at a late stage resulting in genetic variants of TVT Vázquez-Mota et al. (2008). These events can cause genomic instability and lead to progressive modifications that may contribute to its malignant phenotype.

Amaral et al. (2007) demonstrated different cytomorphological types in cytological samples of Transmissible Venereal Tumor. There is a predominance of round cells, scarce cytoplasm, and high nucleus to cytoplasm ratio in the lymphocytic pattern. There is predominance of ovoid cells, ample cytoplasm, and eccentric nucleus in the plasmacytic pattern. The presence of both morphological types does not yield predominance of either in the mixed pattern. According to Bassani-Silva et al., 2007 when TVT cells of lymphocytoid and plasmacytoid morphologies where exposed to extracts of propolis in vitro, the plasmacytoid phenotype was more resistant. This could be an indication that the plasmacytoid TVT is more aggressive than the lymphocytoid.

Considering the absence of data in the literature relating to the molecular characteristics of the different phenotypes of this neoplasia, more research is needed in this area. Thus, the present work aimed to compare the element of LINE-1 transposition inserted into the gene c-myc as a specific genetic alteration of this tumor in cells of canine spontaneous TVT by Polymerase Chain Reaction (PCR) in the groups previously classified as lymphocytoid and plasmacytoid.

Materials and methods

Sample origin and phenotypic classification

The study used 35 dogs of different breeds received at the Veterinary Hospital, FMVZ, UNESP, Botucatu, São Paulo, Brazil. The lesion samples were collected by puncture or exfoliation with consideration to the anatomical localization of TVT. Cellular morphology was evaluated by placing half of the collected material on a microscope slide where it was smears. Slides were subsequently fixed in methanol (Merck, Germany) and stained using the Giemsa method (Merck, Germany). One thousand neoplastic cells per slide were quantified utilizing a polarized light microscope (Axio Imager A1; Carl Zeiss, Germany) connected to a computer program (Axionvision Software Rel. version 4.3; Zeiss Vision, Germany). The TVT was classified as lymphocytoid or plasmacytoid according to the description by Amaral et al. (2007).

The remaining material from each sample was stored in cryotubes (TPP Techno Plastic Products, Switzerland) containing 1.5 mL of buffered saline solution (PBS) (Sigma-Aldrich, EUA), and stored at -20 °C for subsequent extraction of genomic DNA.

Three mL samples of whole blood from animals with and without TVT were collected in EDTA vacutainer tubes (Becton, Dickinson and Company, USA).

Extraction of genomic DNA

Illustra Blood GenomicPrep Mini Spin Kit (Amersham Biosciences, Switzerland) was used to extract the genomic DNA according to the manufacturer’s protocol. The DNA was quantified in a NanoDrop® ND-1000 spectrophotometer (Thermo Fisher Scientific, EUA) and then diluted to 10 ng/µL concentration.

LINE-1 insertion

Identification of the molecular marker LINE-1/c-myc was accomplished by PCR, as described by Chu et al. (2001), using myc.s and LINE.A primers designed by Amariglio et al. (1991) and specific for the LINE-1 segment. The human hemoglobin gene primer (HGBA; Venta et al., 1996), which amplifies a segment of 480 bp, was used as internal reaction control.

The PCR reaction was carried out in 35 one-minute cycles at 94 °C, 1 minute at 64 °C and 1 minute at 72 °C. Each reaction contained 10 ng of genomic DNA, 10 µM of each primer, 4 µL of PCR Master Mix (Promega), and 6 µL of Mili-Q autoclaved water.
DNA sequencing

From all the amplifications, samples of lymphocytoid and plasmacytoid phenotypes were chosen and submitted for sequencing. Direct sequencing reaction followed Big Dye Terminator Cycle Sequencing Ready Reaction kit manufacturer’s protocol (Applied Biosystems, USA). Electrophoresis was completed using an ABI Prism™ 377 DNA Sequencer (Applied Biosystems, USA). The sequences generated were aligned and compared with those deposited at GenBank using the BioEditW version 7.0.4.1 program and the Clustal W Multiple Sequence Alignment Program, v1.7.

Clinical manifestations

The lymphocytoid and plasmacytoid phenotypic groups were classified by age, breed, sex, and localization of genital and/or extragenital neoplasia.

Results

Phenotypic classification

Tumor cells of the 35 dogs were phenotypically classified into lymphocytoid (n=6) or plasmacytoid (n=29).

LINE-1 insertion

The amplified fragments of TVT samples presented approximately 480 bp and 340 bp in reference to the HGBA gene and the target region LINE-1/c-myc, respectively. Conversely, there was no amplification of rearrangement in the PCR negative control (DNA from canine TVT carriers) (Figure 1).

Clinical manifestations

Occurrence of spontaneous TVT in animals (Table 1) varied from three to nine years of age in the lymphocytoid group, and between two to fourteen years in the plasmacytoid group. Both males and females were equally affected by plasmacytoid tumors with no definitive breed predisposition. The external genitalia was primarily affected except in four cases that involved the extra-genital region where the tumor was the plasmacytoid type.
Table 1. Canine spontaneous transmissible venereal tumor: phenotypical and clinical manifestation.

<table>
<thead>
<tr>
<th>Case</th>
<th>Breed *</th>
<th>Age (years)</th>
<th>Sex **</th>
<th>Localization</th>
<th>Morphology</th>
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</table>


Discussion

The mechanisms involved in the development and biological behavior of neoplasias are still mostly unexplained. Nevertheless, results from genetic, biochemical, mutagenetic, and phenotypic studies have supplied extremely important data on the manner by which normal cells are transformed into malignant ones. Genomic instability leads to progressive modifications of the biological profile of these cells, altering their proliferation, differentiation and interaction with the microenvironment, all contributing factors to cell malignancy (Murphy and Jirtle, 2003; Chamary and Hurst, 2009).

Some studies have postulated that detecting the specificity of LINE-1/c-myc rearrangement in cells of spontaneous TVT may explain the appearance, maintenance, and propagation of genetic material in this neoplasia among hosts in different continents for about 200 to 2500 years due to the fact that this...
rearrangement is identical in all of the evaluated cells (Vonholdt and Ostrander, 2006; Murgia et al., 2006; Vázquez-Mota et al., 2008). This specificity was also observed in the samples of the present study, which, in addition to corroborating the data available in the literature, supports the notion that the LINE-1 insertion in the gene c-myc is being conserved and can be utilized as a diagnostic marker of this neoplasia. Furthermore, this abnormality did not differ between the lymphocytoid and plasmacytoid phenotypes.

After sequencing the PCR product, it was verified that part of the LINE-1/c-myc rearrangement was the region actually amplified and similar to sequences available at GenBank (Katzir et al., 1985; Amariglio et al., 1991; Choi et al., 1999; Choi and Kim, 2002; Murgia et al., 2006). The fact that TVT presents phenotypic differences prompted the practice of classifying this tumor as either lymphocytoid or plasmacytoid from 1994 by the Veterinary Pathology Service of FMVZ-UNESP at Botucatu (Amaral et al., 2004; Amaral et al., 2007; Bassani-Silva et al., 2007). As described in table 1, prevalence of the plasmacytoid phenotype was observed compared to the lymphocytoid type.

Considering that some TVTs are resistant to chemotherapy (Brandão et al., 2002) and almost all metastases are associated with plasmacytoid TVT cases (Amaral et al., 2007), it is of clinical relevance to further classify the tumor phenotype.

Changes in the c-myc proto-oncogene can alter cellular metabolism, growth and proliferation, and in turn, be associated with tumoral malignity. The differences in LINE-1/c-myc rearrangement could be involved not only in the phenotypic variation of TVT but may also be implicated in the aggressive activity of plasmacytoid TVT. Although qualitative differences were not observed in this study, comparative quantitative studies are needed between phenotypic groups. It is also necessary to conduct more studies to ascertain the true role of this genetic alteration in TVT, the transposition mechanism, and its role in this neoplasia (Katzir et al., 1985; Amariglio et al., 1991; Choi et al., 1999; Choi et al., 2002).

A clear understanding of TVT pathogenesis differentiated by subtype will provide better methods to advise patients on the best treatment by taking into account the malignancy degree of the tumor. It is important to emphasize that there are no literature reports comparing the two studied phenotypic groups to detect the LINE-1/c-myc rearrangement, so that the current data on this alteration, together with new molecular studies, would help to comprehend the biological behavior of this tumor. Of the 35 dogs evaluated 21 were male and 14 female in spite of the literature, which shows a clear gender predisposition (Cohen, 1985; Das and Das, 2000). The age varied between two and fourteen years, with the highest frequency of affected dogs among those at four years of age. This is due to the fact that these animals have high sexual activity between three and five years of age (Das and Das, 2000; Amaral et al., 2004).

As to breed, 27 (77%) of the 35 animals studied were mixed-breed dogs (WDB), in agreement with descriptions by Brandão et al. (2002), Amaral et al. (2004), and Lefebvre et al. (2007). These authors grouped the WDB dogs into a population characterized as homeless and therefore more exposed to the transmission of this tumor. In both lymphocytoid and plasmacytoid groups the predominant tumor localization was genital in comparison with extragenital sites, corroborating the results by Das and Das (2000) and Nak et al. (2005).

In conclusion, when comparing both phenotype polymorphisms there was no relation to LINE-1 rearrangement in the c-myc gene after sequence alignment obtained in tumors previously classified into the lymphocytoid and plasmacytoid phenotypic groups and, therefore, there appears to be no relation between this analyzed molecular aspect and tumor aggressiveness.

**Acknowledgements**

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References


