XXVI Congresso Brasileiro de Engenharia Biomédica

Armação de Búzios – RJ – Brasil

October 21st to 25th, 2018

Comparison between elastic scattering profiles of canine breast tissues and breast-equivalent materials, through wide-angle X-ray scattering

N. M. P. Oliveira[1*], C. A. Salvego[1], A. C. F. Fagundes[1], P. Zambianchi[1], I. Mazzaro[2], J. K. Zambianchi[1], A. L. C. Conceição[1,3]

[1]Federal University of Technology – Paraná (UTFPR), Curitiba, Brazil

[2]Paraná Federal University (UFPR), Curitiba, Brazil

[3]Photon Science at DESY, Hamburg, Germany

**ndmppo@gmail.com*

Background, Motivation and Objective: Breast-equivalent materials are used in mammography phantoms due to their similarity to breast tissue's elementary composition, density, and attenuation coefficient. There are diagnostic techniques being developed to complement mammography, whose images are generated by the sample's elastic scatter instead of attenuation characteristics alone [1]. To introduce mammary phantoms into these imaging techniques, they must also simulate the tissue's elastic scattering characteristics [2]. Wide-angle X-ray diffraction (WAXS) is a spectroscopy technique that allows to determine the nanostructural organization of a specific specimen. By detecting the elastically scattered photons as function of the scattering angle, it is possible to determine the structural characteristics of each material. On a parallel note, canine mammary tumours have been suggested as a model to study human's due to the great number of similarities between them, from epidemiological data to the histological patterns of the neoplastic lesions [3]. Therefore, it is possible to assume that structural changes observed in canine tumor can also be applied to humans by translational medicine. Although there are some studies applying X-ray diffraction to evaluate human breast tissues [4, 5], for canines data is scarce. Some breast-equivalent materials have been analysed with WAXS [6] and EDXRD (energy-dispersive X-ray diffraction) [7]. It was found that, for adipose tissue, the commercial adipose-equivalent material is a good substitute for human breast adipose tissue, while glandular tissue shows a scattering profile similar to water. The purpose of this research was to compare breast-equivalent materials to canine mammary tissues in terms of their scattering characteristics. Here are presented the scattering profiles for some breast-equivalent materials along with normal and neoplastic canine breast tissues. The results are compared to published data of human breast tissues [4, 5].

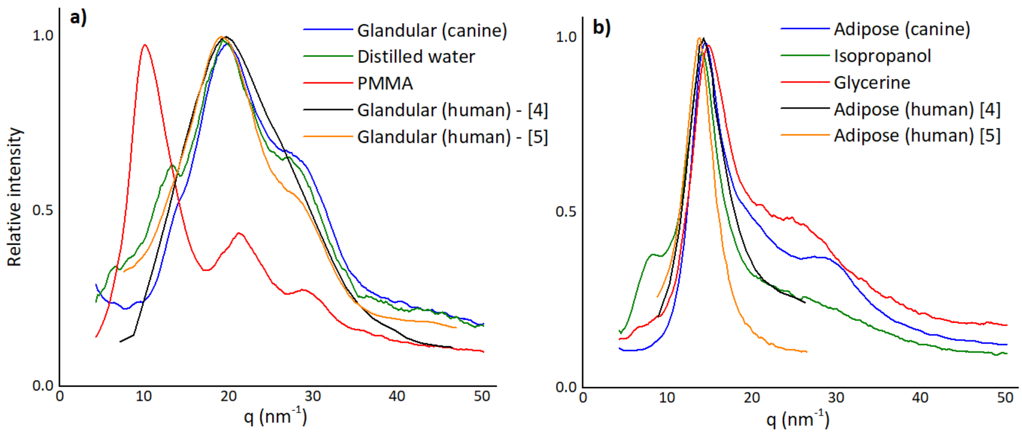
Methods: The canine mammary samples were provided by the Veterinary Pathology Laboratory of UFPR and their use approved by the Ethical Committee for Research with Animal Use (CEUA-UTFPR 2017-029/2017). They were stored in formalin (10% formaldehyde in water) at room temperature. These included a selection of normal (glandular and adipose) and neoplastic canine breast tissues. The breast-equivalent materials analysed were distilled water, glycerine, isopropanol, nylon, polymethylmethacrylate (PMMA) and polypropylene. The experiments were carried out on the XRD-7000 Shimadzu diffractometer, which has a Copper target (Z_{Cu} = 29, $K\alpha_{Cu}$ = 8.04 keV) and a sodium iodide (NaI) detector. The samples were placed on a specially manufactured sample-holder made of polylactic acid (PLA), with 4 mm height and 21 mm internal diameter. The breast-equivalent liquid samples and the biological ones were covered by a thin layer of polyvinyl chloride (PVC). The equipment was set to 40 kVp and 20 mAs, reflection mode, with a momentum transfer range of 4.3 $nm^{-1} < q = 4\pi \sin(\vartheta)/\lambda < 50\ nm^{-1}$, in which θ is the scattering angle and λ the X-ray wavelength, with steps of 1/3 degree. Correction factors related to self-attenuation in the sample, geometric factors, polarization of incoming photons due to the

monochromator and external contributions (air, sample-holder, PVC) were applied. The elastic scattering profiles found for canine breast tissues were plotted against breast-equivalent materials and published data of human breast tissues for comparison.

Results: The fibroglandular tissues presented profiles with a main peak around q = 20 nm^{-1} and a shoulder to the right, around q = 28 nm^{-1}; adipose tissue had a narrower peak at q = 14 nm^{-1}; neoplastic tissues peaks were around q = 21 nm^{-1}. Distilled water presented a main peak at q = 20 nm^{-1}, with a shoulder to the left (q = 14 nm^{-1}) and one to the right (q ≈ 28 nm^{-1}); PMMA's peak was around q = 10 nm^{-1}; isopropanol and glycerin showed peaks at q = 14 and 15 nm^{-1}, respectively; nylon and polypropylene presented profiles with several narrower peaks between 10 and 20 nm^{-1}.

Discussion and Conclusions: PMMA and distilled water are good simulators of fibroglandular tissues when it comes to their attenuation properties. However, PMMA proved to be a poor simulator in terms of elastic scattering, as shown in Figure 1a, while distilled water presented a similar scattering profile to glandular tissues, which is corroborated by the fact that this tissue is constituted by great amounts of water (q = 20 nm^{-1} is equivalent to 3.0 Å, which is the distance between Oxygens in neighbouring water molecules). Isopropanol and glycerin proved to be good scattering simulators for adipose tissues (Figure 1b), since their main peaks are around q = 14 nm^{-1}, which is equivalent to 4.5 Å, consistent with the fatty acids chain. These results prove that not all attenuation-equivalent materials are also elastic scattering-equivalent to breast tissues, so more studies must be conducted to find appropriate materials to produce mammary phantoms to elastic scattering-based imaging.

Figure 1: Elastic scattering profiles found. a) Canine fibroglandular mammary tissue compared to humans [4, 5] and its equivalent-tissues, distilled water and PMMA. b) Canine adipose mammary tissue, also compared to humans [4, 5], and to isopropanol and glycerine.



Acknowledgment: The authors would like to thank the funding agencies CAPES and CNPq.
Keywords. Canine mammary tissue; breast-equivalent materials; WAXS; elastic scattering.

References. **[1]** Johns, P. C. In Opto-Canada: SPIE Regional Meeting on Optoelectronics, Photonics, and Imaging. . p. 103133L, 2017. **[2]** Poletti, M.; Goncalves O. and Mazzaro I. Phys. Med. Biol. 47:47-63, 2001 / **[3]** Visan, S.; Balacescu, O.; Berindan-Neagoe, I.; and Catoi, C. Clujul Medical, 89(1), 38, 2016. / **[4]** Ryan, E. A. and Farquharson M. J. Phys.Med. Biol. 52: 6679–6696, 2007 / **[5]** Oliveira, O. R.; Conceição, A. L.; Cunha, D. M.; Poletti, M. E. and Pelá, C. A. Journal of radiation research, 49(5), 527-532, 2008 / **[6]** Poletti, M. E.; Gonçalves, O. D. and Mazzaro, I. Physics in Medicine & Biology, 47(1), 47, 2001 / **[7]** Geraldelli, W.; Tomal, A. and Poletti, M. E. IEEE Transactions on Nuclear Science, 60(2), 566-571, 2013.