Estimation of breast tumour tissue diffusion parameters from histological images and Monte-Carlo simulations

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Introduction

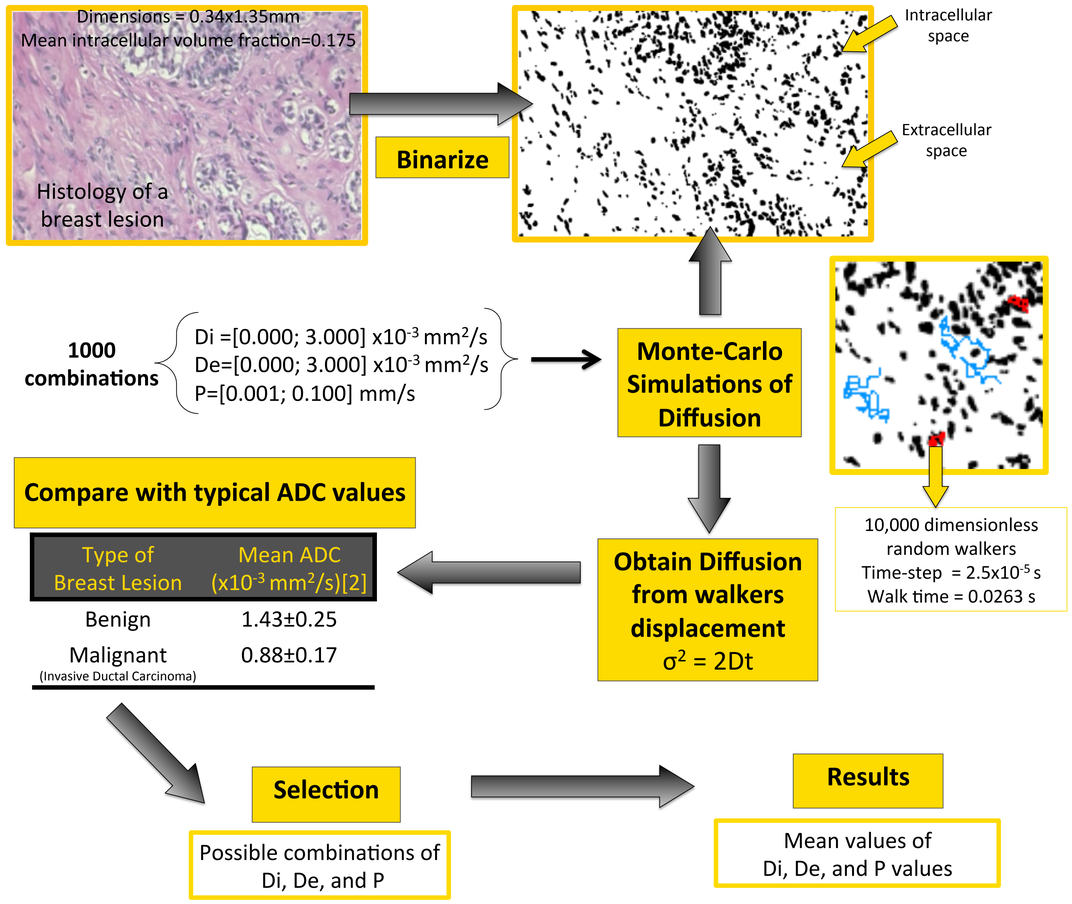
- Diffusion Weighted Magnetic Resonance Imaging (DW-MRI) can differentiate between benign and malignant breast tumours using Apparent Diffusion Coefficient (ADC) [1,2].
- ADC is not able to estimate the intacellular diffusion (Di), extracellular diffusion (De) and Permeability (P) values of the lesions.
- Monte-Carlo Simulations (MCS) of diffusion processes have shown to be useful in characterizing simulated histological environments at the microstructural level [3].

Purpose

Estimate combinations of Di, De and P values that could explain the observed ADC values using MCS on real histological images of benign and malignant breast tumors and thus further characterise tumour tissues.

Methods

Histological images of benign (n=3) and malignant (n=3) breast tumours were analysed [4]. The applied methodology is shown in the fluxogram:



Results and Discussion

- Figure 1 shows the ranges of possible combinations obtained for Di and De.
- Distinct values of De correlate with the breast tumor type (Table 1 and 2).
- The presented approach is able to translate changes in the extracellular medium but is not sufficiently sensitive to depict significant changes in Di and P (Table 1), which could be expected. This may be the result of the low number of images studied and, especially, of the oversimplified processing of the histological images (binarisation only) prior to MCS.

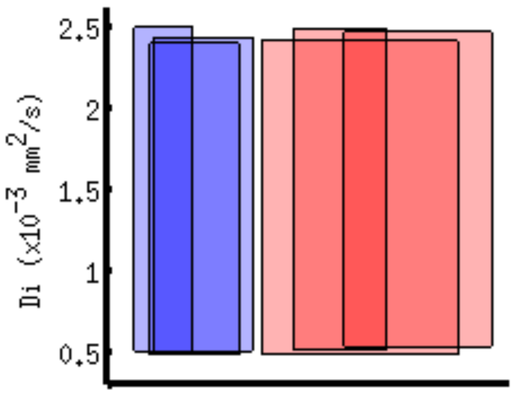


Figure 1. Representation of the ranges of possible (Di,De) combinations for each histological image. Benign tumours in red, malignant tumours in blue. Di – Intracellular Diffusion; De – Extracellular Diffusion.

	Di (x10^{-3}mm^2/s)	De (x10^{-3}mm^2/s)	P (mm/s)
B1	1.48±0.96	2.19±0.33	0.050±0.031
B2	1.44±0.96	1.93±0.44	0.050±0.031
B3	1.49±0.98	1.84±0.21	0.050±0.031
M1	1.43±0.95	1.19±0.20	0.048±0.030
M2	1.39±0.99	1.05±0.13	0.047±0.033
M3	1.46±0.96	1.23±0.22	0.054±0.029

Table 1. Average±standard deviation values obtained for Di, De and P from the tested combinations of these parameters in the MCS for each histological image.
B1 to B3 – Benign breast lesions considered. M1 to M3 – Malignant breast considered. Di – Intracellular Diffusion component. De – Extracellular Diffusion component.

Diffusion component	Type of breast lesions		Biological Correspondence
	Benign	Malignant	
De	Higher	Lower	Higher cellularity [5] of malignant lesions increases the number of barriers for water diffusion in the extracellular medium, consequently reducing the diffusion coefficient of this compartment

Table 2. Differences obtained for extracellular diffusion component for benign and malignant breast lesions, and the respective biological correspondence. De – Extracellular Diffusion.

Conclusion

Distinct combinations of (Di, De, P) are associated with each tumour type.
De revealed to be very distinct for benign and malignant tumors in agreement with known extracellular matrix differences.

References

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