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A sequential grid-block upscaling method for highly heterogeneous tumors: application to osteosarcoma

Monday, 31 May 2021 15:25 (15 minutes)

Osteosarcoma is a primary bone tumour that occurs mainly in adolescents and young adults. The survival rate at 5 years is 70% and drops to 25% for patients with metastases or poor responders to treatment [1]. Therapeutic strategies have not evolved for more than three decades and new developments are needed to improve the specific management of patients.
Like the majority of complex genomic sarcomas, this type of tumours presents strong spatial heterogeneities. In the case of osteosarcoma, there are heterogeneities in bone micro-architecture, cell density but also in the response to treatment due to the potentially localised effect of chemotherapy [2]. Because of the cell populations involved in the evolution of osteosarcomas such as osteoblasts, osteoclasts or osteocytes, it is supposed that osteosarcoma is highly sensitive to the mechanical effects occurring at various spatial scales [3].
At the tissue scale, the osteosarcoma can be considered as porous medium involving various phases (bone, fluid and cells). It is admitted that transport mechanisms and structural deformations play a fundamental role in disease evolution but also on treatment efficiency. Therefore, it is important to determine accurately bone mechanical properties.
The aim of this work is to study different transport mechanisms (interstitial flow, diffusion), structural mechanics (linear elasticity) and poromechanics in the porous tumour at the tissue scale by an approach based on upscaling methods. This methodology rely on histological and immunohistological binarized sections of surgical specimens from a Toulouse patients cohort (CRB Cancer Toulouse). The statistical study of the osteosarcoma micro-architecture shows that the identification of characteristic lengths is complex and that a separation of spatial scales is not necessarily identified. To solve this problem, a sequential grid-block upscaling approach was therefore chosen [4].
We propose to study the 2-step sequential Grid-Block method for each physical mechanism mentioned above. In order to reduce the influence of boundary conditions on the sequential process, an extend-local method has been developed for the first upscaling. These methods have been implemented with the finite element toolbox FEniCS [5]. The dependence to the various methods parameters (boundary conditions, Grid-Block size etc) of the resulting tensors and their properties were studied.
Through this approach, mechanical properties and biological parameters (e.g. cell population density) can be correlated. It is then possible to obtain new quantitative mecano-biological information on bone tumours from patients follow-up images and potentially to obtain markers useful in patient-specific treatment management.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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