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A mathematical model to predict the diagnostics periods for the secondary distant metastases in patients with ER/PR/HER2/Ki-67 subtypes of breast cancer

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Introduction

Previously, a mathematical model of primary tumor (PT) growth and secondary distant metastasis (sdMTS) growth in breast cancer (BC) (CoMPaS), considering the TNM classification, was presented [1]. Goal: To detect the diagnostic periods for visible sdMTS via CoMPaS in patients with different subtypes ER/PR/HER2/Ki-67 of breast cancer.

Methods

The model CoMPaS is based on an exponential growth model and complementing formulas, and the model corresponds to the TNM classification and subtypes ER/PR/HER2/Ki-67 classification. CoMPaS allows calculating the tumor volume doubling time (TVDT) of the PT and sdMTSs and the earliest diagnostic period of sdMTSs. The CoMPaS model reflects: 1) subtypes of BC such as ER/PR/HER2/Ki-67, where Luminal A = HR(+)/HER2(-), Luminal B = HR(+)/HER2(+), Luminal B = HR(+)/HER2(-), HR(-)/HER2(+) and HR(-)/HER2(-), depending on the TVDT_{MTS}; 2) the growth processes of the PT and sdMTSs in BC patients without or with lymph node metastases (MTSs) in accordance with the 8th edition AJCC prognostic staging system for breast cancer [2].

Results

Critical growth periods of BC are defined via CoMPaS: (1) the non-visible growth period of the PT; (2) the non-visible growth period of the sdMTSs; and (3) the visible growth period of the sdMTSs. CoMPaS correctly describes the growth period of the PT, which corresponds to the TNM and ER/PR/HER2/Ki-67 subtypes classification, the growth period of the sdMTSs and the 1-15-year survival of BC patients, taking into account TNM and ER/PR/HER2/Ki-67 subtypes classification. CoMPaS correctly describes the growth of the PT in ER/PR/HER2/Ki-67 subtypes of BC patients and helps to calculate the different diagnostic periods, depending on the TVDT_{MTS}, when sdMTSs might appear.

Discussion

CoMPaS and the corresponding software tool can help: (1) to optimize the process of detecting the different diagnostic periods for sdMTSs in BC patients with different tumor subtypes ER/PR/HER2/Ki-67 and the growth rate of the PT and sdMTSs; (2) to start the early treatment of small sdMTSs in BC patients with different tumor subtypes ER/PR/HER2/Ki-67; (3) to increase the survival of BC patients with sdMTSs of different tumor subtypes ER/PR/HER2/Ki-67; and (4) to consider the patient to be almost healthy if sdMTSs do not appear during the different diagnostic periods.

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