Purpose: To study the role of intravascular microbubble-induced heating resulting from in-vivo low-intensity sonication of solid tumors using contrast-enhanced ultrasound images.

Methods: Solid tumors are modeled as a compressible inhomogeneous medium that consists of a network of micro-blood vessels in a microenvironment of cells and interstitial fluids through which microbubbles flow. A mathematical model based on the Penne Bioheat equation was used to calculate the microbubble-enhanced temperature increase during sonication of solid tumors. This mathematical framework was applied to contrast-enhanced ultrasound images to simulate the in-vivo conditions of antivascular ultrasound therapy.

Results: The results show that the presence of microbubbles causes local heating in the tumor at the locations of the microbubbles in the image. The temperature initially increases rapidly initially as a function of time and then levels off. The temperature elevation calculated as a function of sonication frequency, show that, the maximum temperature change occurs near the resonance frequency of the microbubbles. The mathematical simulations also show that as the flow rate increases, the temperature elevation decreases.

Conclusions: Our results show that microbubbles circulating in the blood provide a mechanism for delivering acoustic energy at the location of the microbubbles. Since previous experimental studies show that sonication of intravascular microbubbles disrupt tumor microvessels, antivascular ultrasound treatment has the potential for treating patients with cancer.