Title: Dynamic response to heat - a novel physical characteristic of breast cancer

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Dynamic response to heat
- a novel physical characteristic of breast cancer.

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Contribution: JSV conceived the idea, CAP dissected and interpreted the specimens, JSV and CS took the thermal images with the help of CAP and CS analysed and superimposed the images. SIB and TF discussed the thermophysics. JSV wrote the first draft and all authors contributed to the manuscript.

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Abstract

We report a novel observation about breast cancer. We imaged six fresh pathological specimens of breast cancer (1 mastectomy and 5 lumpectomies) with a sensitive infrared camera. We found that, following exposure to hot air for 1 minute, the cancers warmed up much less than the surrounding normal breast with a difference ranging from 12-20°C. We believe that this physical property of cancer should be explored and may give us better insight into the nature of cancer, its diagnosis (including intraoperative diagnosis) and targeted treatment.

Introduction Cancer has been assessed in many different ways, but there is only very limited knowledge about the thermal properties of human pathological specimens[1,2]. We assessed whether breast cancer behaved differently after a thermal challenge.

Method In our pathology laboratory, routine assessment of mastectomy and lumpectomy specimens involves making coronal slices of the fresh resection. These slices are then visually inspected and photographed (Figure 1a and 2a). We took thermal images of such slices, about 1 hour after surgery, using two very sensitive thermal cameras (for the mastectomy: Cedip Infrared Systems, France, sensitivity 0.02°C; for the lumpectomies: FLIR E45, FLIR Systems Inc., USA, sensitivity 0.10°C), at room temperature and following exposure to hot air for 1 minute.

Results We found that in every specimen examined, the tumour warmed up less than the surrounding normal breast tissue. maximum The temperature differences were remarkably large varying from 12.4 to 23.3°C (median 18.65) respectively. The margin of the tumour was very clearly demarcated (Figure 1).

Discussion A higher thermal diffusivity of cancerous breast tissue was reported by Valvano et al. This may partly explain the differential thermal response; heat will dissipate into the breast cancer tissue more rapidly than it does in the surrounding tissue, thus limiting its surface temperature rise. However, this, and other, physical properties of breast cancer need further investigation to elucidate the exact mechanism for the observed differential heating and determine the general applicability of the technique to other solid tumours.

This difference in thermal properties between cancerous and normal breast tissues could have wide implications. The difference in response to heat may be related to various factors such as the relative proportions of water, fatty, fibrous or vascular tissue, or indeed malignant tissue, and understanding the role of these – and any other – factors could lead to new insights. Subtle differences (with well standardised measurements) may be found between tumours that are traditionally classified under one heading or grade. Thus thermal response may one day become a very useful prognostic or predictive parameter. With the recent advent of low cost, high resolution thermal imaging instruments, it could perhaps be used for rapid intraoperative assessment of margins or to find multifocal tumours. If significant differences in *dynamic* thermal response to heat challenge - as opposed to just one static ambient measurement - are identified *in vivo*, then they could be used to selectively target tumour tissue and spare normal tissues by temperature dependent activation of a drug. More importantly, investigation into the nature and causation of this new physical characteristic may open new doors to our understanding of cancer.

References

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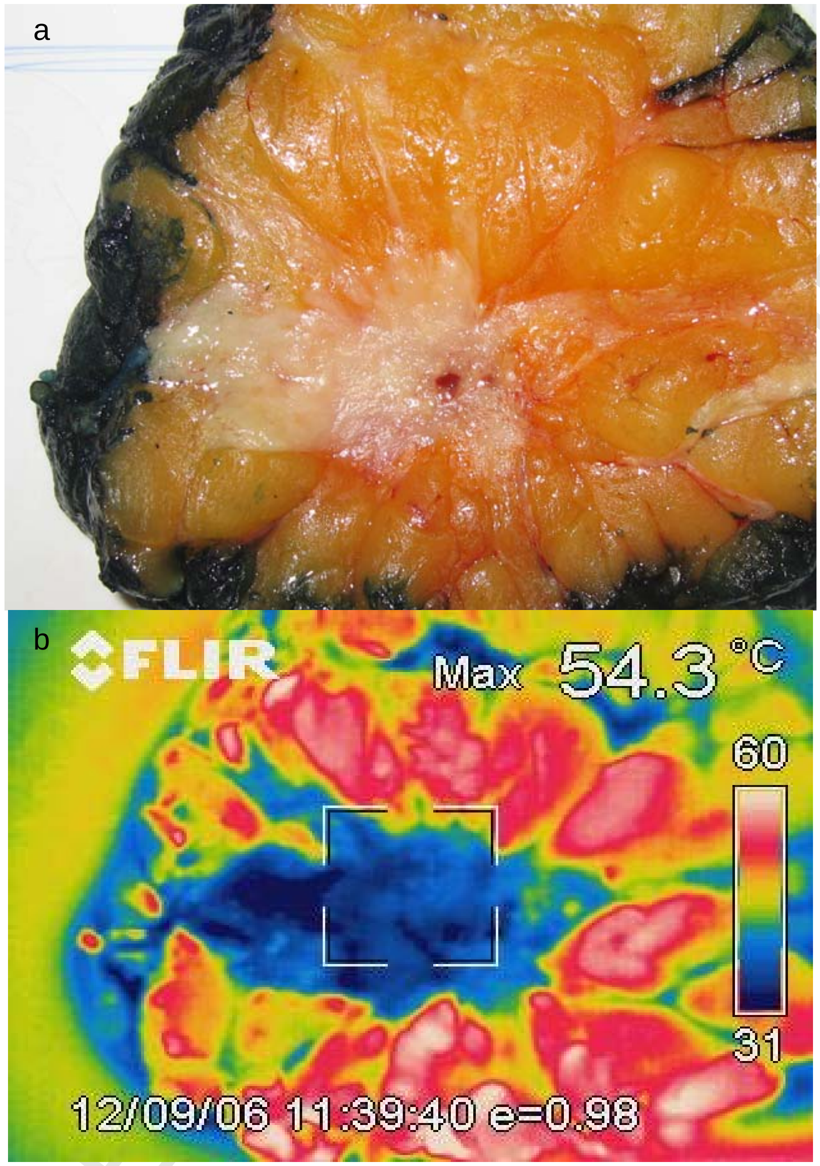
FIGURE 1



Legend: Figure 1a is the digital photograph of a slice from a lumpectomy specimen. The whitish area is the breast cancer. Figure 1b is the thermal image after exposure to heat for 1 minute. The scale is on the right of the figure.