# Localized $^{13}$C NMR spectroscopy in the human breast *in vivo*

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## Introduction

$^{13}$C magnetic resonance spectroscopy is a useful non-invasive tool allowing the assessment of glucose metabolism *in vivo*. This approach has already been used to study the mechanisms underlying tumor glucose metabolism *in vivo* in rat brain (1) and in mice breast tumors (2), and *ex vivo* in normal and cancerous human breast tissue (3). To our knowledge, it has never been applied to human breast *in vivo*. Here, we show for the first time localized $^{13}$C spectra of the normal human breast *in vivo*.

## Materials and Methods

All experiments were carried out on a 4T whole-body (90 cm) Oxford magnet equipped with a Varian console. A linear transmit/receive $^{1}$H surface coil with a linear $^{13}$C surface coil designed for breast studies was used. The spectroscopy method utilized $^{1}$H localization with 3D-ISIS, coherence transfer to $^{13}$C using DEPT, and proton decoupling (WALTZ-16) during acquisition (4). Three healthy volunteers (ages 18-43) were examined in a study approved by our institutional review board. The SAR was kept at a value of 3 W/kg (below the FDA guidelines). Sensitivity of the used method was estimated using a phantom containing a solution of 100 mM [1-$^{13}$C] glucose.

## Results

Spectra were acquired in each subject with voxel sizes ranging from 1 to 48 ml, and placed in both adipose and fibroglandular tissue. The spectra exhibited resonances of natural abundance $^{13}$C from acyl chain residues (cf. figure 1 b and c). Peaks were in excellent agreement with data obtained from tissue biopsies (3). On the figure, the image shows the location of a 48 ml and a 1 ml voxel. Corresponding spectra are shown on the left, showing an excellent sensitivity (3). The main peaks are distinguishable even on the small 1 ml volume, which is a typical size used in MRS of breast tumors. The *in vivo* sensitivity, as determined on a phantom after correction for coil loading and linewidth, was estimated to be 0.8 mM of $^{13}$C label for an 8-ml voxel acquired in 6 minutes.

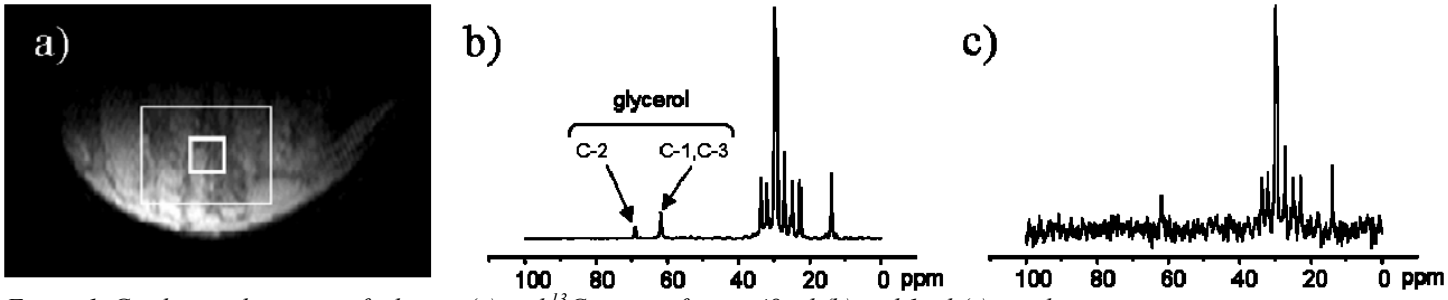


*Figure 1. Gradient-echo image of a breast (a) and $^{13}$C spectra from a 48 ml (b) and 1 ml (c) voxels.*
*The image shows a sagittal view of a breast. The voxels locations are outlined. Acquisition of spectroscopic data in one voxel took about 6 minutes. Spectra result from an average of 128 scans. A 5 Hz line-broadening was applied in both cases. Peakswere assigned according to Victor et al. (3). Peaks from 14 to 34 ppm are resonances attributable to different acyl chain residues.*

## Conclusion/Discussion

This is the first study demonstrating the feasibility of $^{13}$C MRS in breast *in vivo* at 4T. In addition to the information obtained from natural abundance $^{13}$C spectroscopy of lipids, some of which may possibly be specific for malignancy, these preliminary results open the prospects of detecting $^{13}$C-labelled metabolites (e.g. lactate) after infusion of $^{13}$C-labelled glucose. This approach is expected to provide new tools for non-invasive detection and therapeutic monitoring of malignancies in the human breast.

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**References. 1.** Terpstra M et al., Cancer Res 1998;58(22):5083-5088. **2.** Rivenzon-Segal D et al., Am J Physiol Endocrinol Metab 2002;283(4):E623-630. **3.** Victor TA et al., Br J Cancer 1993;68(2):336-341. **4.** Henry PG et al., Magn Reson Med 2003;50(4):684-692.