Evaluation of CADstream™ for serial automated breast tumor volume measurements in patients undergoing neoadjuvant chemotherapy for breast cancer

B. N. Joe[1], A. Urioste[2], K. Vahidi[1], J. Gibbs[1], E. Proctor[1], Z. Siraj[1], Y. Lu[1], N. Hylton[1]

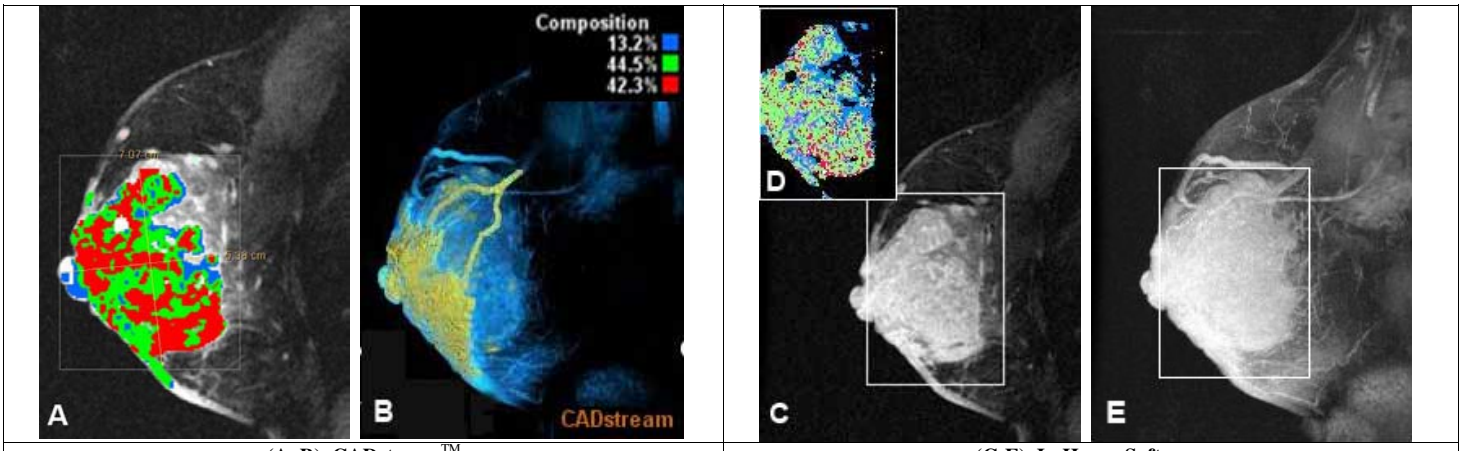
[1]Radiology, University of California, San Francisco, San Francisco, CA, United States, [2]Radiology, University of California, San Diego, San Diego, CA, United States

Introduction

MRI breast tumor volume has recently been shown to be predictive of length of recurrence free survival (LRFS) [1]. This study evaluates a software package (CADstream™, Confirma, Inc.) for automated serial measurement of breast MRI tumor volumes in response to treatment and compares results to established in-house software.

Methods

Thirty-one patients (mean age 50, range 32-71 years) receiving neoadjuvant chemotherapy for locally-advanced breast cancer underwent dynamic breast MRI at 1.5T before, during, and after treatment. Tumor volumes were automatically determined using CADstream™ and using previously established in-house software, both based on summing voxels with an enhancement threshold of 70% over initial (pre-contrast) signal intensity (Sample volume measurements in one patient shown in Fig.1). Volume response was calculated as the percentage change in tumor volume pre- and post-treatment. LRFS was calculated as the time between surgery and occurrence of local or distant metastases or death. For patients who did not recur, LRFS was taken as the time between surgery and the most recent follow up. Agreement between the two methods was assessed with Bland-Altman regression analysis. Cox regression model was used to assess age-adjusted relative risk (RR) for each of the two volumes. Bootstrap method was used to compare differences in derived RR by the two methods.



(A, B) CADstream™ | **(C-E) In House Software**

Fig. 1. Sample automated tumor volume measurements in a patient with a large invasive ductal carcinoma using CADstream™ (A-B) and in house software (C-D). (A) Representative slice from a sagittal post-contrast 3D gradient echo T1 image through the breast with CADstream™ color overlay marking the extent of tumor. (B) Colorized maximum intensity projection (MIP) image in the same patient generated with CADstream™ software. (C) Corresponding slice as shown in (A) with color map showing tumor volume (D) produced by in-house software. (E) Corresponding MIP image as shown in (B) produced with in-house software.

Results

Volumes measured by the two methods were highly correlated. Correlation coefficients for serial volume measurements ranged from 0.71 to 0.95 ($p<0.0003$ for all). Scatter plot of baseline volume measurements is shown in Fig. 2. Change in volume from baseline to last visit was also highly correlated ($r=0.81$, $p<0.0001$). Bland-Altman regression analysis suggested the two methods were exchangeable ($p>0.96$ for all visits as well as percentage changes). Age adjusted RR per cm^3 increase in tumor volume was 1.020 with a 95% confidence interval of (0.997,1.044) for baseline CADstream™ volume, which was very similar to RR for volume measured by our software (RR=1.014, 0.997-1.029). These RR's were insignificantly different from zero based on bootstrap analysis. Mean and standard deviation of tumor volume measurements for the two methods for each MR visit are given in Table 1.

Table 1. Comparison of volume measurements using CADstream™ and in-house software.

MRI visit number	n	CADstream™ Mean (SD)	In-House Mean (SD)	p-value for equal means*	p-value for no difference**
1 (baseline)	31	32 (31)	31 (38)	0.77	0.99
2	21	12 (17)	15 (22)	0.89	0.99
3	27	5 (10)	4 (6)	0.64	0.99
4	11	3 (5)	3 (4)	0.85	0.96
5 (final exam)	31	6 (12)	5 (8)	0.53	0.99
% change (vol. response)	31	-82% (21)%	-77% (20%)	0.04	0.99

* Paired t-test for mean differences between two methods. P-value >0.05 means difference is not statistically significant. ** P-value of Bland-Altman regression for exchangeability between two methods. A p-value >0.05 means the two methods are interchangeable. Mean volumes and standard deviations (SD) given in cm^3.

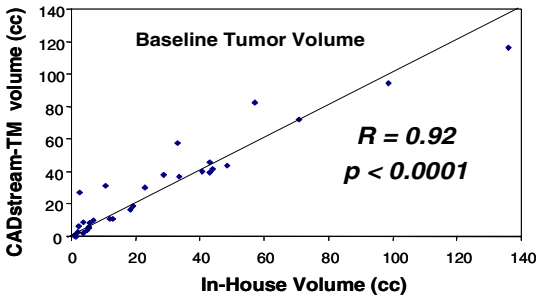


Fig. 2. Scatter plot of baseline breast tumor volumes shows excellent correlation between volumes measured by CADstream™ (vertical axis) and volumes measured by our established in-house software (horizontal axis). Diagonal black line is line of identity. (R=.92, p<0.0001)

Discussion

CADstream™ produced similar results to those reported previously using in-house software. The reproducibility of results using commercially-available software supports the robustness of volumetric measurements of tumor response as a surrogate endpoint for survival outcomes.

Reference 1. Partridge SC, et al. AJR 2005; 184:1774-1781.