Clinical Advantages of Automated CT Tumor Measurement

Lesion measurement has long been an inexact science. Yet, judging the patient's disease regression or progression is, to a large extent, based on documentation of exact changes in tumor size. Currently, when tumor masses are encountered in daily clinical practice, manual measurements made with electronic calipers are utilized. These are quite time consuming and not reliably exact from examination to examination.

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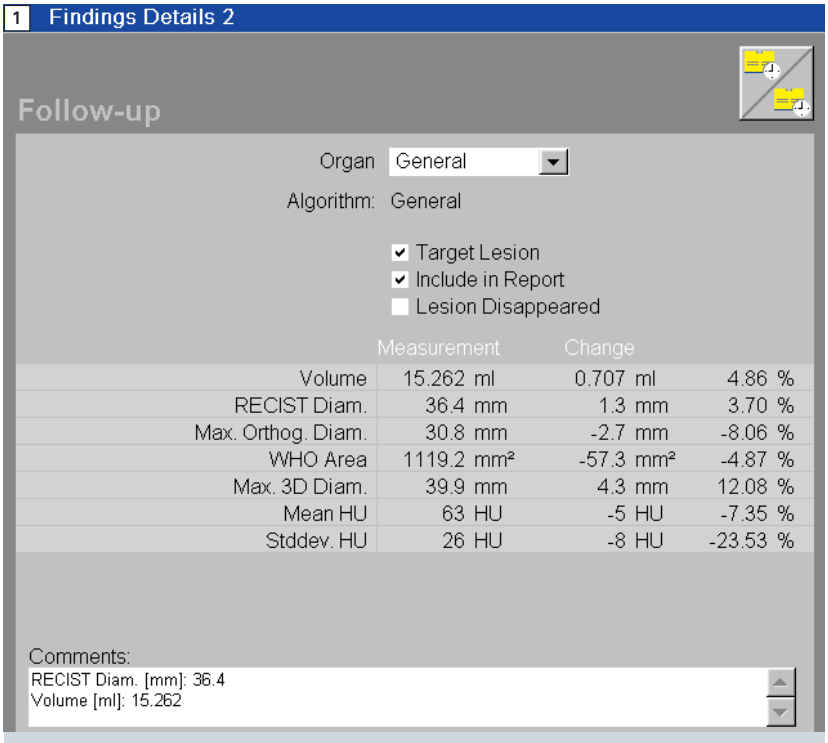
Because tumors are complex shapes, the axis of measurement chosen over serial time points may vary. RECIST (Response Evaluation Criteria in Solid Tumors) has been widely adopted in the U.S. and WHO (World Health Organization) criteria elsewhere as the standard reporting parameters for lesion size. Among many problems with these methods, constraining measurements into the axial plane may under- or overestimate the longest diameter of the lesion.
If software could be developed to segment the 3D volume from an MDCT data set, the truest approximation of the maximal diameter (RECIST diameter) could be determined. Additionally, such software should be able to "store" this information so that the same exact lesion could be followed over the course of the patient's treatment, thereby eliminating variances in manual measurement. Finally, converting these observations onto a spreadsheet would aid institutional compliance in clinical trial, with benefits not only to improved patient care, but also increased opportuni-



1 All segmentation and measurement results are stored and reported. The list includes the most important lesion information, such as WHO and RECIST diameters, Volumes and their changes since the last examination. A comprehensive report, including key images, can be generated and stored.

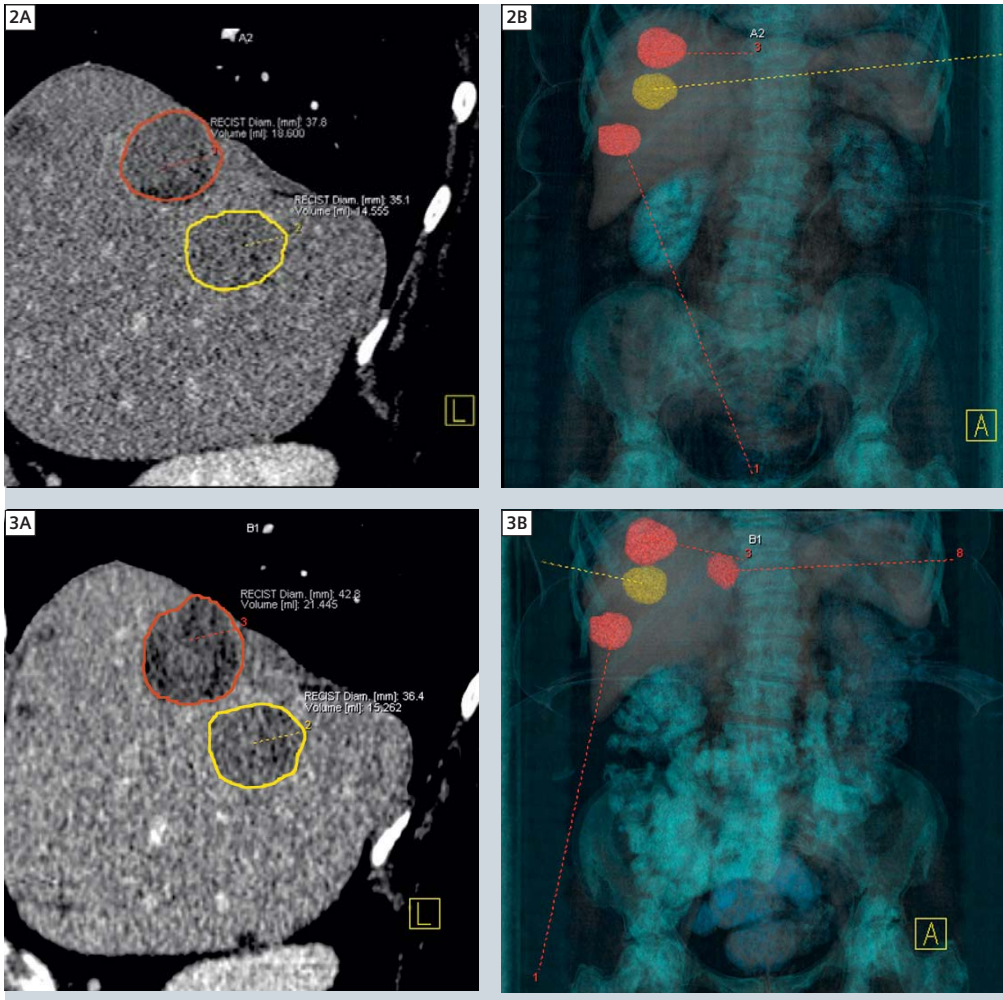
ty for ongoing funding, since it improves the institution's ability to record data in a usable format.
Siemens *syngo* CT Oncology is a clinically available suite of tools that provides all these capabilities (Fig. 1).

Algorithm Refinement

In preliminary testing of the *syngo* CT Oncology algorithm, 27 hepatic metastases in 13 patients were evaluated using prototype software that defined the edges, maximal and orthogonal diameters of the targeted lesion. The auto-segmented measurements were compared to manual measurements made by electronic calipers, and the difference between the two was recorded.
As a prototype, this algorithm performed well: Using 4 mm slices, long diameters of 67 percent of metastases of less than 5 mm were correctly measured within 2 mm of the manual measurement. With this information, the algorithm was further refined.
In our next evaluation of the actual, clinical application, it performed exceptionally well. Eighty-seven hepatic masses from 33 patient studies were evaluated. Here, we sought to compare the tool's ability to obtain RECIST diameters of hepatic metastases against manual evaluation of the same lesion. There was a high degree of concordance between RECIST diameters obtained using automated segmentation versus manual measuring. In fact, 74 percent of lesions differed by less than 5 mm. A finding of particular importance: the *syngo* CT Oncology segmentation algorithm is independent of absolute HU measurements. Thus, there is no dependence on the quality of the contrast injection, which makes the tool particularly valuable for serial observations of lesions in patients where it is difficult to obtain a good injection (such as those undergoing chemotherapy).

Comprehensive Evaluation and Reporting

With *syngo* CT Oncology, the lesion is presented in axial, coronal and sagittal displays with RECIST and WHO measurements, and volume. The radiologist can decide whether to accept the results or edit, if necessary. Evaluation results are comprehensively presented and the images stored to PACS, ensuring that any follow-up measurements are conducted with a consistent approach to the correct lesion(s). This is particularly helpful in following tumor progress.



2 **3** Example of a 73 year old female patient with known carcinoid on treatment. Follow up is performed in a 3 month interval (Figs. 3A-B). The datasets are automatically registered and displayed synchronously for easy follow-up comparison. The lesion is then identified in both studies and is automatically segmented and evaluated. Sagittal and 3D reformats are shown (Figs. 2A-B – base exam, Figs. 3A-B – 3 month follow up).

Future Directions

RECIST and WHO criteria do not currently include volume; it is the next, expected step in comprehensive tumor measurement. It is theorized that volume may be more sensitive to tumor growth than diameter because lesion diameter can remain consistent while volume changes. Clearly, the ability to measure volume is an asset, even if it has not yet been clinically validated. We are currently in the process of comparing changes in volume against diameter changes as measured with RECIST criteria.
With its ability to record and evaluate all tumor parameters, *syngo* CT Oncology is an advantageous tool for the radiologist. This software helps solidify the role of the radiologist as someone who goes beyond simple diagnosis, but rather, a physician who, through the use of a wide variety of image processing tools, can provide information that directly impacts therapeutic decisions.