ORIGINAL ARTICLE

Fast and accurate liver volumetry prior to hepatectomy

Toine M. Lodewick[1,2], Carsten W.K.P. Arnoldussen[3], Max J. Lahaye[3], Kim M.C. van Mierlo[1], Ulf P. Neumann[1,2], Regina G. Beets-Tan[3], Cornelis H.C. Dejong[1,2] & Ronald M. van Dam[1,2]

[1]Department of Surgery, Maastricht University Medical Center & NUTRIM School of Nutrition & Translational Research in Metabolism, Maastricht University, Maastricht, The Netherlands, [2]Department of Surgery, University Hospital Aachen, Division of General, Visceral and Transplantation Surgery, Aachen, Germany, and [3]Department of Radiology, Maastricht University Medical Center, Maastricht, The Netherlands

Abstract

Background: Volumetric assessment of the liver is essential in the prevention of postresectional liver failure after partial hepatectomy. Currently used methods are accurate but time-consuming. This study aimed to test a new automated method for preoperative volumetric liver assessment.

Methods: Patients who underwent a contrast enhanced portovenous phase CT-scan prior to hepatectomy in 2012 were included. Total liver volume (TLV) and future remnant liver volume (FRLV) were measured using TeraRecon Aquarius iNtuition® (autosegmentation) and OsiriX® (manual segmentation) software by two observers for each software package. Remnant liver volume percentage (RLV%) was calculated. Time needed to determine TLV and FRLV was measured. Inter-observer variability was assessed using Bland-Altman plots.

Results: Twenty-seven patients were included. There were no significant differences in measured volumes between OsiriX® and iNtuition®. Moreover, there were significant correlations between the OsiriX® observers, the iNtuition® observers and between OsiriX® and iNtuition® post-processing systems (all $R^2 > 0.97$). The median time needed for complete liver volumetric analysis was 18.4 ± 4.9 min with OsiriX® and 5.8 ± 1.7 min using iNtuition® (p < 0.001).

Conclusion: Both OsiriX® and iNtuition® liver volumetry are accurate and easily applicable. However, volumetric assessment of the liver with iNtuition® auto-segmentation is three times faster compared to manual OsiriX® volumetry.

Correspondence

Toine M. Lodewick, Department of Surgery, Maastricht University, PO Box 616, 6200 MD, Maastricht, The Netherlands. Tel: +31 43 3881547, +31 43 3875473. E-mail: T.lodewick@maastrichtuniversity.nl

Introduction

Postresectional liver failure (PLF) remains the most important factor associated with postoperative mortality after major liver resections (resection of 4 or more Couinaud liver segments).[1–3] Prevention of this severe and often lethal complication is attempted through pre-operative CT-based volumetric liver assessment in patients undergoing major liver resections.[4–6] In patients with healthy livers approximately 25% of the liver parenchyma needs to be preserved to prevent PLF.[7] In damaged or cirrhotic livers up to 50% liver parenchyma needs to be spared.

The standard technique for liver volumetry is CT based (semi-) manual delineation of liver borders. This volumetric assessment is relatively time-consuming.[4–6] Additionally, with traditional software, the total liver volume, future remnant liver volume and tumour volume all need to be outlined separately in order to make a proper risk-assessment prior to large liver resections, further increasing the time required for complete analysis.[4,6]

With specialised software, auto-segmentation of organs is possible.[8–14] However, CT-based automated segmentation of the liver is challenging because organs with comparable density surround the liver. Automated future remnant liver volumetric analysis has not yet been validated by comparing it with manual slice-by-slice drawing of contours. Recently, automated liver segmentation has been introduced in a new version of TeraRecon Aquarius iNtuition® which is user friendly and easy to

learn. Moreover, a 'virtual cut' option is available, which is timesaving as it directly provides the future remnant liver volume after performing the cut on the reconstructed total liver volume.

This study aimed to validate auto-segmentated liver volumetry using the iNtuition® software and investigate the time saved with this new method compared to semi-manual outlining of the liver contours using traditional software (OsiriX®).
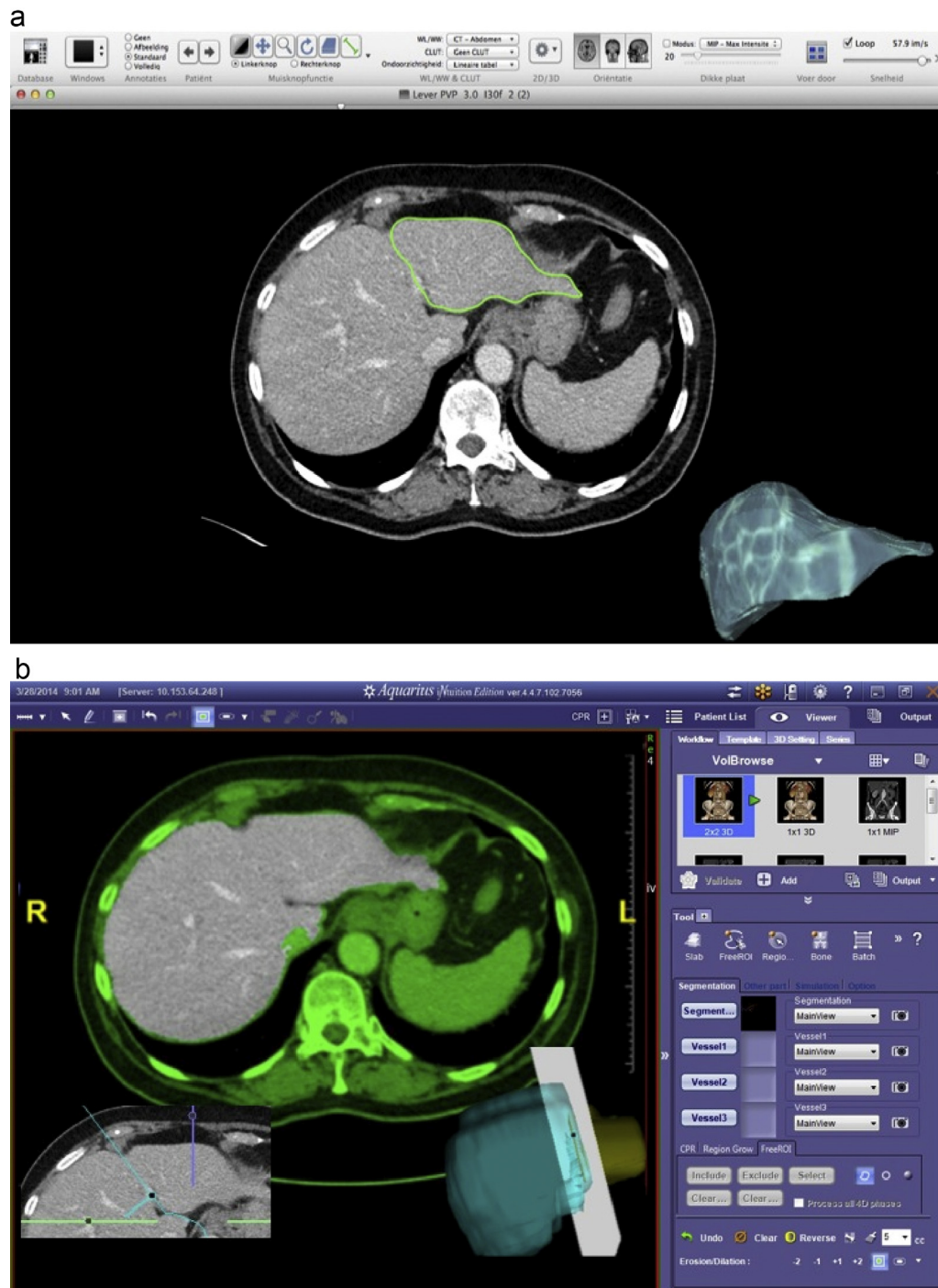

Figure 1 a. OsiriX® semi-manual volumetric assessment, with reconstruction (right bottom); b. INtuition® auto-segmentation with "virtual cut" function (left bottom), reconstruction (right bottom)