Use of Computerized Tomography with Thin Slice Thickness in Liver Volumetry: Review Article

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Abstract

Introduction: Liver volumetry is becoming essential for increased liver transplantation need. Different modalities of scanning are used to obtain liver volumetry. Although ultrasound scanning is the safest non invasive method but it is totally operator dependent hence low reliability. Computerized tomography scanning was used more than other modalities of imaging. Magnetic resonance imaging also used but delineation of the liver from nearby structures is not easily reproducible. Moreover, 3D image acquisition in MRI takes longer time during scanning and so patients with claustrophobia may not be compliant. This study aimed to review which modality of scanning had been commonly applied and reported in the period 2000 – 2015.

Methodology: Searching was made through www.google.com , www.pubmed.gov , www.ask.com and www.medscape.com search engines. Reports in English about liver volumetry in adult patients scanned by computerized tomography or magnetic resonance imaging were retrieved. Computed liver volume, slice thickness and contrast uses were compared between CT and MRI. Results were tested in SPSS 19.

Results: CT with contrast was commonly used than MRI. Slice thickness of 1 -3 mm was the most frequently taken. The average liver volume in CT was 1244.25 ml ± 449.5 while in MRI was 1156 ml ± 917.4. Uses of automated and semi automated methods significantly exceeded the use of manual methods.

Conclusions: Contrast enhanced computerized tomography with slice thickness 1-3 mm was commonly used in liver volume measurement. Numerical value of liver volume was not different between CT and MRI. Manual measurement was the least to be applied.

Keywords: Liver volumetry, Slice thickness, Computerized tomography, Liver volume measurement, MRI liver volumetry, CT liver volumetry, Liver volume measurement.

1 INTRODUCTION

Liver transplantation is increasingly used due to the growing incidence of end stage liver failure. It is considered as a safe and efficient treatment for such cases. [1] The assessment of donor for liver transplant includes evaluation of liver parenchyma and volume. Therefore, measurement of volume for the total or segment of the liver is essential for assuring appropriate graft size; hence successful outcome for both living donor and the recipient.[2] In the past, the data about donor's liver was obtained only through invasive techniques such as biopsy and injection of contrast media. Currently, liver volume obtained from imaging modality is becoming a routine method to complete donor - recipient matching. [3]

CT-scan is considered as a reliable method for liver assessment. It is used in the determination of hepatic arterial, venous anatomy, the source of segment IV artery, and portal vein variations. Moreover, it is also applied in the evaluation of bile ducts as well as liver volume measurement.[4] On the other hand, magnetic resonance imaging (MRI) has been used to assess the liver size in order to decrease the number of investigations and avoid potential nephrotoxic iodinated contrast agents. [5] Many studies tried to validate different imaging techniques for liver volumetry, but there is no clear evidence about the most accurate method for evaluation. [6]

Automated liver extraction scheme for measuring liver volume was applied by some researchers comparing the manual method with automated interactive volumetry. (2) The difference was proved to be not statistically significant but the automated was highly time saving. (2), [7], [8], [9], [10], [11], [12], [13]

Slice thickness in CT imaging varied between protocols. While some used slice thickness of 5mm [14] others used 3 mm. [15]
The difference between the semi-automated methods by CT and the postoperative volume measurement of liver segment was proved to be statistically not significant. [16],[17]
On the other hand, MRI was also used in liver volumetry [18], [19], [20]. Some authors used computer based software for volume measurements by MRI scans. The error was found to be less than 30%. Difficulties in demarcation of liver boundaries were attributed to low resolution. [21] Contrast enhanced MRI was used to improve the resolution but it was still limited by the overlap of the kidney which made liver segmentation inaccurate. [22] Section thickness in MRI scanning was found to influence the accuracy in the results of volume measurements. [23]

Reports on precise determination of the liver boundaries were scanty.[24] There was consensus between researchers in exclusion of the gall bladder and the inferior vena cava as well as extra hepatic part of hepatic vein from the liver volume. (21), [25],[26]
This study aimed to survey reports describing the different methods for measurement of liver volume using CT and MRI scans during the period 2000 to 2015.

2 METHEDOLOGY

Meticulous searching was done through the following search engines; www.Google.com , www.pubmed.gov , www.ask.com and www.medscape.com looking for literature about liver volume measurement between the years 2000-2015, using the following keywords; liver volumetry; MRI liver volumetry; Computerized tomography; liver volume measurement; slice thickness.

The search embraced reports about liver volumetry by CT and MRI scans. The exclusion criteria were the following:

- Volumetry by ultrasound.
- Pediatric patients.
- Any report before 2000.

The inclusion criteria were:

- Volumetry by MRI and CT scans.
- With or without contrast.
- Automated or manual methods.
- English reports between 2000-2015.

The data was analyzed in SPSS 19. One way ANOVA test was obtained for the significance of difference in volume between CT and MRI.

3 RESULTS

The results of the study were presented in form of tables:

Table 1: Modalities of scan per year:

Year interval	CT	MRI	Total
2000 – 2005	2	3	5
2006 – 2010	5	4	9
2011 – 2015	8	4	12
Total	15	11	26

Table 2: Contrast use in CT vs. MRI:

Year interval	CT		MRI		Total
	With	Without	With	Without	
2000 – 2005	2	0	1	2	5
2006 – 2010	5	0	3	1	9
2011 – 2015	7	1	2	2	12
Total	14	1	6	5	26
	15		11		

Table 3: Automated/semi-automated vs. Manual methods:

Imaging modality	Automated/semi-automated	Manual	Total
CT	14	1	15
MRI	11	0	11
Total	25	1	26

Table 4: Slice thickness used in CT and MRI scanning studies:

Slice Thickness	CT studies	MRI studies	Total number of studies
1-3 mm	9	2	11
4-6 mm	1	3	4
7-9 mm	0	2	2
10-12mm	1	1	2
Total number of studies	11	7	19

Table 5: Average Liver Volume in mls Obtained by CT and MRI Scans:

Imaging modality	No. of patients	Number of articles	Volume Average in ml	SD
CT	807	9	1244.25	449.5
MRI	307	6	1165.00	917.4
Total	1114	15	2,409.25	1,366.9

- P value 0.189

4 DISCUSSIONS

The study investigated reports about liver scanning by CT and MRI for volume measurements considering contrast use, time saving and slice thickness as well as consistency in liver volume. The search focused on the period 2000 to 2015.

Although MRI is of less hazards compared to CT since there is no fear of ionizing radiation in it [17], but the amount of CT application was found to exceed that of MRI. The number of patients scanned with CT ranged between 10-337 in the recorded studies, while those of MRI ranged between 5 and 116. The higher number of patients scanned by CT may indicate reliability of data obtained by CT more than that obtained by MRI. Contrast was frequently used in CT studies compared to MRI as well as in recent CT studies compared to the old studies. The high degree of resolution in CT with contrast made it more popular because it improved the level of accuracy as well as no reported harmful effects. The use or non use of contrast in MRI was found to be equal.

Almost all the studies used automated and semi-automated methods rather than the manual procedures in volume measurement. This could be justified by the significant time saving achieved by applying automated methods in both MRI and CT scans. [7, 8, 9]

Despite the importance of assessing the difference in time spent during scanning the patient by CT and MRI, yet all the harvested studies did not report on this difference. The short duration of scanning by CT compared to MRI is believed to be one of the reasons for preference of CT especially in patients with claustrophobia.

Regarding the slice thickness, it was found that slice thickness of 1-3 mm was common in CT than in MRI. It was reported that, using of more than 5mm slice thickness will result in under-estimation of the actual volume while slice thickness less than 2.5mm gives an over-estimated volume.

Total liver volume measurement when using both CT and MRI scans was nearly without a significant difference. It ranged between 500-2000 ml in both imaging modalities with standard deviation between 200-600 ml.

Limitation of the study could be summed up in difficulty in accessibility of website and retrieving full text of most of the articles.

5 Conclusions

Contrast enhanced computerized tomography with slice thickness of 1-3 mm was found to be commonly applied mean of liver volumetry. Numerical value of liver volume showed no significant difference between CT and MRI. Automated/semi-automated methods were highly time-saving compared to the manual method.

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