Single phase split-bolus versus triphasic 64-detector row CT technique in the detection and characterization of focal liver lesions in oncological patients

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Purpose

Advances in Multidetector-row CT (MDCT) technology have resulted in an increase in imaging speed and have enabled both the acquisition of thinner slices and an increase in z-axis coverage with significant benefits especially in the initial diagnosis and follow-up of oncologic patient [1, 2]. The organ whose imaging is most affected by advances in MDCT is the liver.

The goal in hepatic imaging is to increase the difference in enhancement between the two tissues in order to maximize the conspicuity of lesions. In the oncologic patients, MDCT occurs both in the identification and characterization of liver lesions with a significant impact on the therapeutic approach.

In addition to benefits of MDCT, there are two important implications:
1) the enormous amount of data to be analyzed;
2) the radiation dose to the patient due to multiphasic studies or repeated whole-body CT scans to monitor the response to therapy [3-8].

The rationale is a revisitation of conventional CT protocols designed to reduce the number of images and the radiation dose to the patient focusing to an accurate diagnosis and diagnostic quality images with the same results of bi- or triphasic CT technique.

The aim of our retrospective study is to verify and to compare the results of monophasic "Split-bolus" 64-slice CT technique with those of triphasic CT in the detection and characterization of focal liver lesions.
Methods and Materials

We retrospectively reviewed the 64-detector row CT performed at our institution, between June 2010 and July 2011, by double-bolus injection and single phase acquisition technique (Protocol A) in 36 patients (24 males and 12 females; age range 42-80 years, mean age 63.3 years; weight between 50 and 75 kg, mean weight 60 kg) in follow-up for extrahepatic primary tumor with at least one focal liver lesion and already underwent triphasic CT protocol (Protocol B) (gold standard).

The patients had cysts (n = 54), typical haemangiomas (n = 8), atypical haemangiomas (n = 12), metastases (n = 26) and focal nodular hyperplasia (n = 1). The lesions size varied from 1.5 mm and 18 mm for cysts, from 3 mm and 10 mm for typical haemangiomas, from 1.1 mm and 17 mm for atypical haemangiomas, from 25 mm and 47 mm for metastasis; maximum diameter for focal nodular hyperplasia was 52 mm.

The patients were affected by colon-rectal cancer (n=12), lung cancer (n=12), non-Hodgkin lymphoma (n=1), bladder cancer (n=3), pancreatic cancer (n=2), breast cancer (n=1), ovarian cancer (n=2), GIST (n=2) and gastric cancer (n=1). In all patients the primary neoplasm was confirmed histologically.

The examinations were performed with a 64 slice CT scanner (Philips Brilliance, Best, The Nederlands) using the following parameters: matrix: 512 x 512, slice thickness: 2.0-2.5 mm, reconstruction index: 1.0-1.25 mm, gantry rotation speed: 0.75 seconds, pitch: 0,935:1; 120 kVp and automatic tube current (mA) using Z-axis dose modulation (Z-DOM).

Nonionic contrast agent at 320-370 mgI/mL concentration was injected in double bolus from an antecubital vein through a 16-18-gauge needle, in a quantity ranged from 90 mL to 150 mL.

The protocol diagram of 64 detector-row CT with double split-bolus intravenous contrast medium technique in oncologic patients is reported in Fig. 1 on page 5.

The images of Protocol A, in terms of detection and characterization of the liver lesions, were evaluated by two radiologists and compared with those of the Protocol B.

The effective dose (mSv) was determined by multiplying a conversion factor for the dose-length product (DLP).

Split-bolus MDCT technique

The "Split-bolus" technique protocol by monophasic acquisition after the intravenous injection of two boluses of organic iodine contrast material is reported in Figure 1. First bolus: at the start of bolus injection (time zero) 55-90 mL (1.4 mL/kg) were injected at
1.2-1.5 mL/sec followed by 20 ml of saline solution at the same flow rate to determine enhancement in the vascular system. Second bolus: 35-60 mL (1.0 mL/kg) at 3.5 mL/sec followed by 20 ml of saline solution at the same flow rate were injected to achieve the arterial phase. Scan begins at least after 6 seconds from the time of arrival of the contrast material into the aorta determined by bolus tracking. CT delayed phase (5 minutes) of the liver was performed in some cases.

**Dose Radiation Calculation**

The radiation was measured in effective dose (Sievert, Sv) which was calculated using dose-length-product (DLP) values in mSv by conversion factors of MDCT taken from the 2004 Quality Criteria for MDCT (6).
Fig. 1: Diagram protocol of 64-detector row CT with double Split-bolus intravenous contrast medium technique of the liver in oncologic patients. The contrast material is injected in two boluses, each one reduced of 15 mL because contrast material was followed by saline solution. First bolus: at the start of bolus injection [or time zero], 55-90 mL (1.4 mL/kg) were injected at 1.2-1.5 mL/sec followed by 20 ml of saline solution at the same flow rate to determine enhancement in the vascular system. Second bolus: 35-60 mL (1.0 mL/kg) at 3.5 mL/sec followed by 20 ml of saline solution at the same flow rate were injected to achieve the arterial phase.

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Results

Split-bolus 64-detector row CT compared with triphasic MDCT technique allowed similar results in the detection of liver lesions in oncologic patients. In particular in the characterization of liver lesions, Split-bolus CT determined the same patterns compared with triphasic MDCT technique (Fig. 2 on page 7, Fig. 3 on page 7, Fig. 4 on page 8, Fig. 5 on page 9, Fig. 6 on page 10).

A significant reduction of the radiation dose was obtained by Split-bolus CT technique with respect to triphasic CT (the mean dose of radiation was 15.85 ± 3.8 mSv for protocol A and 23.26 ± 4.7 mSv for protocol B) (Fig. 7 on page 11).
Fig. 2: Triple phase CT of hepatic cysts in arterial phase (a), venous phase (b) and delayed phase (c). 64-detector row CT with double Split-bolus intravenous contrast medium technique (d) and delayed phase at 5 minutes (e) shows a similar pattern.

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**Fig. 3:** Triple phase CT of a typical hepatic haemangioma with a peripheral globular enhancement in arterial phase (a), venous phase (b) and delayed phase (c). 64-detector row CT with double Split-bolus intravenous contrast medium technique (d) and delayed phase at 5 minutes (e) shows a similar pattern (peripheral enhancement that extends toward the center).

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Small atypical hepatic haemangioma with rapid flow

Fig. 4: Triple phase CT of a small atypical hepatic haemangioma (9) in arterial phase (a), venous phase (b) and delayed phase (c). Single-pass 64-detector row CT with double Split-bolus intravenous contrast medium technique (d).

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Focal Nodular Hyperplasia (FNH)

Fig. 5: Triple phase CT of a focal nodular hyperplasia (FNH) in arterial phase (a), venous phase (b) and delayed phase (c). Single-pass Split-bolus CT technique (c) and delayed phase at 5 minutes (e) demonstrate a similar pattern.

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Liver metastasis

Fig. 6: Triple phase CT of a hypodense liver metastasis in arterial phase (a), venous phase(b) and delayed phase(c). Single-pass 64- detector row CT with double Split-bolus intravenous contrast medium technique (d) and delayed phase at 5 minutes (e) shows a similar appearance.

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### Dose radiation to patient: Split-bolus CT vs triphasic MDCT technique

<table>
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<tr>
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<th>SPLIT-BOLUS TC</th>
<th>TRIPHASIC CT</th>
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<tbody>
<tr>
<td>Effective dose (mSv)</td>
<td>15.85 (± 3.8)</td>
<td>23.26 (± 4.7)</td>
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Note: in parenthesis are indicated the values of standard deviation.

**Fig. 7:** Dose radiation to patient: Split-bolus CT versus triphasic MDCT technique.

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Conclusion

The diagnostic accuracy of 64-detector row CT with Split-bolus is comparable to that of triphasic MDCT technique with a significant reduction in radiation dose and quantity of images to be analyzed.
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Personal Information

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