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Contrast enhanced abdominal computerised tomography using a reduced volume of high concentration iodinated contrast medium to achieve a dose reduction.

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Abstract:

Aim: To evaluate whether a reduced volume of high concentration iodinated contrast material could be used in abdominal computerised tomography (CT) to achieve an iodine load reduction without adversely affecting image quality.

Materials and methods: 150 portal venous phase abdominal CT investigations were reviewed retrospectively and the degree of visceral opacification measured using the liver as representative. Two groups of patients were studied whom received either either 100 ml of Optiray 300 mg/ml or 75 ml of Optiray 350 mg/ml intravenous contrast material prior to the CT.

Results: The iodine dose was lower in the 75 ml Optiray 350 group (26.25 g group) than the 100 ml Optiray 300 group (30 g group). Mean CT density of liver parenchyma was statistically significantly lower in the 26.25 g group 80 HU 95 % CI (78.2, 82.0) vs the 30 g group 86.6 HU 95 % CI (83.7, 89.6). Both protocols achieved diagnostically acceptable images with liver opacification above 50 HU in at least 95%. The 30 g group achieved liver opacification above 50 HU in 95 % of cases, the 26.25 g group achieved liver opacification above 50 HU in 98.5%.

Conclusion: A modest reduction in the dose of administered intravenous contrast may be achieved by mildly reducing the mean visceral opacification but without adversely affecting the diagnostic value of the images obtained.

Introduction: Iodinated compounds within an organ increase the rate of photon absorption and scatter [1] which enhances the detection of visceral pathology by increasing the contrast resolution of tissue.[2] Optimisation of tissue contrast enhancement is important for achieving diagnostic quality images and detection of pathology however, iodinated contrast medium may cause a nephropathy commonly referred to as contrast induced nephropathy but more correctly known as contrast induced acute kidney injury.[3] CIN includes an absolute (> or = 0.5 mg/dl) or relative increase (> or = 25%) in serum creatinine up to 72 hours following exposure to contrast medium compared to baseline serum creatinine values when other causes of renal impairment have been excluded.[4] The risk of contrast medium induced nephropathy is increased with increasing doses of contrast medium [5,6] and contrast medium induced nephropathy is associated with increased morbidity and mortality.[7] The number of CT studies performed is rapidly increasing; putting more patients at risk of CIN.[3,8] Therefore compromise must be made between the risks associated with an increased contrast dose and the potential for missed pathology associated with lower contrast material doses.[3] Recently it has been demonstrated that reduced quantities of iodinated contrast material can be used for CT pulmonary angiography without adversely affecting pulmonary arterial enhancement using a multiphasic injection protocol.[9] Similarly, the reduction in dose of intravenous contrast material could be extended to CT examinations of other regions.

To test this assumption, we aim to study the effects of varying iodinated contrast material dose upon contrast enhancement of the abdominal viscera demonstrated by CT images.

At our institution disparate doses of iodinated contrast material are employed for performing abdominal CT based purely on the preference of individual consultants. Two different preparations are used; a high volume of lower concentration contrast and a low volume of higher concentration iodinated contrast material: 100ml of 300mg iodine/ml and 75ml of 350mg iodine/ml which provide 30g and 26.25g iodine respectively.

This paper will present the effect of varying the dose of administered iodinated contrast material upon opacification of viscera within CT images of patients undergoing abdominal CT imaging.

Materials and Methods: The Audit and Research Department at our institution deemed ethical approval for this retrospective study unnecessary, the need for informed consent from the included patients was also not considered necessary.

Patients undergoing portal venous phase contrast enhanced abdominal CT were selected sequentially during a seven month period from February 2012 to September 2012 from clinical investigations carried out in our institution. The patients were identified retrospectively from the logbooks of studies which were maintained by the CT radiographers in the department.

Two patient groups were identified for comparison based upon the dose of iodinated contrast material administered. The first group underwent abdominal CT following a 30g dose of iodinated contrast material by means of 100ml of 300mg/ml Optiray 300 (Mallinckrodt Pharmaceuticals). The second group underwent abdominal CT after receiving a lower dose of iodinated contrast material using 75ml of 350mg/ml Optiray 350 (Mallinckrodt Pharmaceuticals).

It was aimed to recruit 60 patients in each group. Patients undergoing portal venous phase abdominal or abdomen and pelvis CT were included. Studies incorrectly coded as abdominal / pelvic CT but undergoing alternative abdominal studies were excluded due to the change in enhancement characteristics of the images that a study acquisition in an alternative phase would deliver. Studies of patients with gross liver pathology were also excluded since such lesions could prevent reasonable assessment of the normal liver parenchyma.

Image assessment was performed by a single investigator using an Insignia workstation. The reader was blinded to the dose of iodinated contrast material administered for each examination and the studies randomised prior to review.

Radiodensity of the liver, in Hounsfield Units (HU), was assessed by measuring region of

interest radiodensity measurements in three areas: Couneaud segments II, VII and either IVa or VIII depending on which allowed measurement of the parenchyma without including the middle hepatic vein within the region of interest. Uniformly sized regions of interest between $300mm^2$and $400mm^2$ were acquired in order to minimise potential random variation of photon flux density. Care was taken to avoid major vessels and macro pathology within the liver parenchyma.

Further parameters were assessed using regions of interest and length measurements which included: Depth (cm) of subcutaneous fat anterior to the rectus sheath just above the level of the umbilicus in the axial plane, opacification (HU) of the middle hepatic vein, opacification (HU) of the portal vein just distal to the confluence, opacification (HU) of the aorta and of the spleen.

Abdominal CT examinations were performed using a 32 slice General Electric CT scanner (Lightspeed 32, GE Healthcare, Waukesha, WI, USA). Scan parameters required slices of 1.25mm thick, a pitch of 1:1.375, voltage of 120KV and variable current. Bolus tracking using a region of interest within the liver; acquisition commenced when the attenuation of the liver increased by 40 HU. A Mallinckrodt Optivantage automatic injector pump was used to deliver 3 or 4 ml per second at the discretion of the attending radiographer based upon the likely maximal flow within the patients intravenous canula.

Statistical analysis of the data was achieved using Excel Statistics (Microsoft Corporation 2010). Sample data was assessed for normality using frequency charts. Differences in the mean average of test groups were compared using T-Test models. Alpha probability was set at 0.05 and confidence levels assessed at 95%.

Results: 150 cases were studied. 186 cases were initially identified. 36 were excluded prior to image assessment for the following reasons; 16 showing extensive liver pathology, 8 of a study type other than abdomen and pelvis, 6 showed a discrepancy in the records regarding the dose of iodinated contrast media administered and 5 had extensive missing data. There were 60 patients in the 100ml Optiray 300 group and 90 in the 75ml Optiray 350 group.

The mean depth of subcutaneous fat was 2.7cm (SD 1.1cm) in the 100ml Optiray 300 group and 3.0cm (SD 1.3cm) in the 75ml Optiray 350. These mean points were not shown to be significantly different ($p = 0.22$).

The measured depth of subcutaneous fat was not shown to be different between the two groups. This was measured as a surrogate for body weight or body mass index which was unavailable at the time of the study.

The mean CT density of liver parenchyma is shown in Figure 1.

Figure 1. Box and whisker plot showing the mean measured attenuation values of liver parenchyma of cases receiving either 100 ml Optiray 300 or 75 ml Optiray 350. Whiskers demonstrate 95 % confidence intervals.

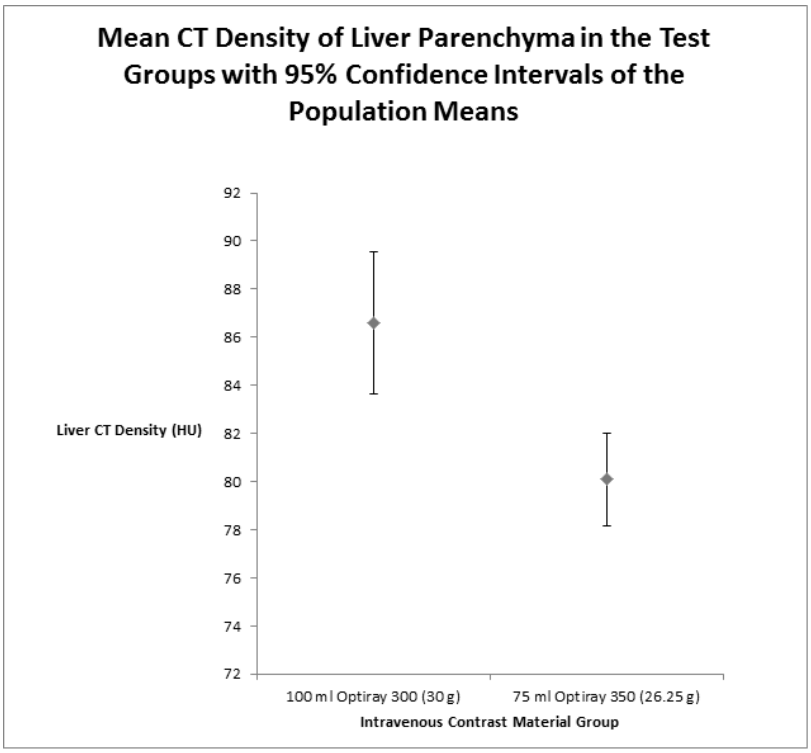

Figure 1. Box and whisker plot showing the mean measured attenuation values of liver parenchyma of cases receiving either 100 ml Optiray 300 or 75 ml Optiray 350. Whiskers demonstrate 95 % confidence intervals.

The mean CT density was significantly lower in the 75ml Optiray 350 than the 100ml Optiray 300 group. The difference between the two means was 6.5 HU (1.7 to 11.4; 95% CI).

The distribution of attenuation values measured are shown in Figures 2. and 3.

Figure 2. Bar graph showing the frequency of measured values of liver density (HU) on abdominal CT of the patients receiving 100 ml Optiray 300 (30 g Iodine).

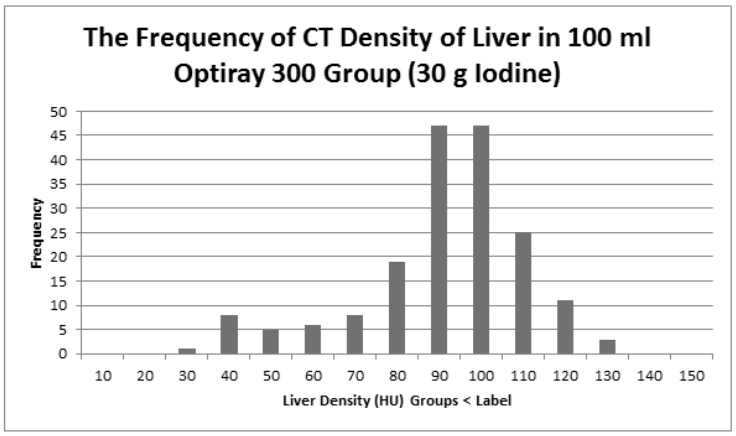

Figure 2. Bar graph showing the frequency of measured values of liver density (HU) on abdominal CT of the patients receiving 100 ml Optiray 300 (30 g Iodine).

Figure 3. Bar graph showing the frequency of measured values of liver density (HU) on abdominal CT of the patients receiving 75 ml Optiray 350 (26.5 g Iodine).

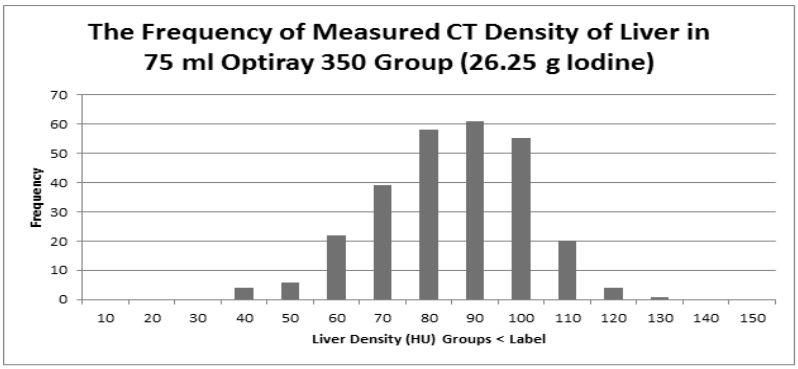

Figure 3. Bar graph showing the frequency of measured values of liver density (HU) on abdominal CT of the patients receiving 75 ml Optiray 350 (26.25 g Iodine)

The numbers of measurements determined at below 50 HU was lower in the 75ml Optiray 350 (4 of 270 measurements, 1.5%) group than the 100ml Optiray 300 group (9 of 180 measurements, 5%).

Discussion: The diminishing visceral opacification associated with reducing the infused volume of contrast medium is well documented.[2,10,11] Administering a reduced dose of iodine by reducing the volume of contrast and increasing its concentration has a more complicated contrast enhancement profile.

We have shown that reducing the total dose of iodine significantly reduces the mean liver opacification. The impact of this reduction on diagnostic capability has not been investigated. However, Brink et. al. (1995) considered that liver attenuation values above 50 HU were diagnostically acceptable.[12]We have demonstrated that there is little difference between the number of CT studies achieving this 50 HU thresh-hold, indeed the lower dose group achieved a higher percentage of studies above this thresh-hold than the higher dose group. It is of interest that despite lower mean liver opacification, the lower dose injection resulted in considerably fewer scans with attenuation values of the liver below the 50HU threshold.

There was only a small difference in the attenuation of liver parenchyma following the different doses of iodinated contrast media. However, the different doses of iodinated contrast media given were only 3.75g different (13% different by total weight of iodine administered).

The similarity of the two groups' depth of subcutaneous fat is used in this study to demonstrate similarity in body habitus between the two groups. This was used as a surrogate for BMI which was not available at the time of the study.

Conclusion: This study demonstrates that a modest reduction in the dose of administered intravenous contrast may be achieved without adversely affecting the diagnostic value of the images obtained. Utilisation of this reduced dose of contrast when acquiring CT images will reduce the risk to patients of contrast induced nephropathy.

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