**Determination of correction factors for incorrect injection rate during dce-ct examinations.**

**Aim:** To derive individualized correction factors that enable the recorded nodule enhancement values to be adjusted for the incorrect injection rate

**Method:** A linear systems approach was used as follows:

Finj \* IRFc = AIF

AIF \* IRFn = NEC

where Finj is the time-dependent function describing the contrast material injection, IRFc the impulse response function for the passage of contrast material through the central circulation, AIF the arterial input function, IRFn impulse response function for the passage of contrast material through the nodule, NEC the nodule enhancement curve and \* the convolution function. Two contrast material injection functions were modelled representing injections of 3ml/s for 40s and 2ml/s for 60s respectively, resulting in the administration of identical total quantities of iodine. Both IRFs of initial height (h) comprised a 5s minimum transit time followed by a single exponential decay (k). Analysis was performed using 5s time increments. IRFcwas estimated by deconvolution of the observed AIF against the 3ml/s injection function. The injection function for 2ml/s was then convolved with IRFcto estimate the AIF that would have been observed for the slower injection rate. IRFnwas estimated by deconvolution of the observed NEC against the 3ml/s AIF. The NEC for a 2ml/s injection was then convolved with IRFnto estimate the NEC that would have been observed for the slower injection rate. Correction factors for 60, 120, 180 and 240s were determined by comparison of the NECs for 3ml/s and 2ml/s. The calculated correction factors were validated by comparison with published data

**Results:** The initial heights (h1, h2) and decay constants (k1, k2) for IRFc and IRFn respectively are shown for 3 DCE-CT studies in table 1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Case #** | MS703 | MS705 | MS706 |
| **k1** | 0.00329 | 0.00346 | 0.00635 |
| **h1** | 5.922 | 6.473 | 8.270 |
| **k2** | 0.0205 | 0.0243 | 0.00615 |
| **h2** | 0.0463 | 0.0472 | 0.0272 |

Table 1: IRF characteristics

The correction factors for the lower contrast injection rate for each case are given for each time point in table 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Case #** | MS703 | MS705 | MS706 |
| **60s** | 0.804 | 0.810 | 0.785 |
| **120s** | 0.984 | 0.994 | 0.952 |
| **180s** | 1.019 | 1.025 | 0.995 |
| **240s** | 1.029 | 1.033 | 1.015 |

Table 2. Correction factors

The correction factors would significantly decrease the enhancement value at 60s (19.6-21.5%) and mildly decrease enhancement at 120s (0.6-4.8%) but produce little change in attenuation values at 180s and 240s (-0.5% - +3.3%). These findings are illustrated by the calculated AIFs and NECs for MS706 as shown in figure 1.



Figure 1: Modelled AIFs and NECs for injection rates of 2ml/s and 3ml/s for case MS706.

A literature search [CT + enhancement + injection + rate] identified no studies reporting the impact of injection rate on the enhancement of pulmonary nodules. Most studies reported the impact of injection rate on hepatic enhancement but these reports were not considered further in view of the dual blood supply to the liver. Two studies described the impact of injection rate on pancreatic enhancement. This organ has a single blood supply and is therefore comparable to the blood supply for pulmonary nodules. Using image acquisitions every 5s for a total of 73s, Tublim et al reported a 29% increase in peak pancreatic enhancement when increasing the injection rate for a 150ml bolus from 2.5 ml/s to 5ml/s [1]. Using image acquisitions every 2s for a total of 60s, Kim et al reported increased in peak pancreatic enhancement of 10% and 16% when increasing the injection rate from 3ml/s to 5ml/s for injections of 2ml/kg and 1.5 ml/kg respectively [2]. A kinetic model using a single blood supply reported by et al Bae et al with imaging acquisitions of up to every 15s to a total time of 300s described a 3% increase in peak tissue enhancement when the contrast injection rate was increased from 2ml/s to 4ml/s [3]. The reduced impact found in the latter likely reflects the lower frequency of image acquisitions which could result failure to capture peak tissue enhancement within the imaging protocol. The correction factors identified above (table 2) are in keeping with these previous reports.

**References:**

Mitchell E. Tublin, Franklin N. et al. Effect of Injection Rate of Contrast Medium on Pancreatic and Hepatic Helical CT. Radiology 1999;210: 97–101

Tonsok Kim, Takamichi Murakami, Satoru Takahashi et al. Pancreatic CT Imaging: Effects of Different Injection Rates and Doses of Contrast Material. Radiology 1999;212: 219–225

K T Bae, J P Heiken, J A Brink. Aortic and hepatic peak enhancement at CT: effect of contrast medium injection rate--pharmacokinetic analysis and experimental porcine model. Radiology 1998;206: 455–464