Interobserver variation of CT and FDG-PET based GTV for oesophageal cancer: a Dutch nationwide study
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Purpose or Objective: Interobserver variation in target definition is a major contributor to geometric uncertainty in radiotherapy and consistent GTV delineation is crucial in dose escalation studies for oesophageal cancer. The routine use of FDG-PET for target delineation in oesophageal cancer patients treated with chemoradiation is debated in the literature. The aims of this study were to evaluate the interobserver variation of GTV delineation in The Netherlands and the impact of adding FDG-PET to CT images on interobserver variability in patients with oesophageal carcinoma.

Material and Methods: Six cases were included from a prospective database of oesophageal carcinoma patients. All cases underwent a planning FDG-PET/CT scan in treatment position. Twenty upper gastro-intestinal dedicated radiation oncologists from 14 institutes in The Netherlands independently delineated the GTV first on CT, using additional clinical and diagnostic information. Secondly, they adjusted this GTV after CT and FDG-PET images were fused. As general metrics for interobserver variability, volumes and generalized conformity indices were calculated. For visual comparison of interobserver variation observer count maps were generated for each case, i.e. maps of voxels showing the number of enclosing observer delineations. To quantify the interobserver variation at the cranial and caudal border, the distance along the z-axis that contains 5-95% of the observers was used.

Results: Significant differences in delineated GTV volumes were observed in 4 out of 6 cases after addition of FDG-PET to CT (Table 1). In 3 cases there was a significant volume reduction, whereas in one case a significant volume increase was found by PET, caused by unsuspected continuation of the tumour in the stomach. Generalized conformity indices were comparable for CT and FDG-PET/CT (Table 1). Count maps revealed that interobserver variation was mainly located at the cranial and caudal border (Figure 1A). The median observer variation was 26 mm (range 6-36 mm) at the cranial border and 18 mm (range 3-30 mm) at the caudal border (Figure 1B). Even after addition of PET interobserver variation remained more than 20 mm in 4 out of 6 cases (Figure 1B). In 2 cases a reduced interobserver variation was seen with PET/CT at the cranial border and in another 2 cases only at the caudal border. An increased variation was seen with PET/CT compared with CT at the caudal border for the case with the unsuspected FDG uptake in the stomach.

Conclusion: This nationwide Dutch contouring study in oesophageal cancer demonstrated that in daily clinical practice considerable GTV delineation variation is present, with variations up to 36 and 30 mm at the cranial and caudal border, respectively. Although FDG-PET significantly impacted the delineated volume in two-thirds of the patients, the addition of PET did not translate into an observer variation below 20 mm in 4 out of 6 cases.
Purpose or Objective: In pancreatic cancer, the delineation of target volumes on a CT scan can be difficult due to poor contrast between tumour and surrounding tissues. This study quantifies, for pancreatic cancer in the Netherlands, the interobserver variation of delineated gross tumour volume (GTV) and the internal GTV (iGTV: the volume encompassing GTV in all ten phases of the respiratory cycle) on three-dimensional CT (3DCT) and four-dimensional CT (4DCT), respectively.

Material and Methods: Seven radiation oncologists from six institutions, with an average of 5 irradiated pancreatic patients per year (range: 3-10), delineated pancreatic tumours in four patients with (borderline) resectable pancreatic cancer. First, the GTV was delineated on a contrast-enhanced 3DCT under guidance of an arterial and venous contrast-enhanced diagnostic scan. This contrast-enhanced 3DCT scan was obtained during free breathing, using a GE LightSpeed RT16 scanner. The GTV was expanded with a fixed margin of 5 mm to create the CTV. In the same session, a 4DCT scan, without contrast enhancement, was obtained, during which the respiratory motion of the patient was monitored to reconstruct 10 respiratory phase scans. Second, the iGTV was delineated on the 4DCT, under guidance of the diagnostic CT and expanded with a fixed margin of 5 mm to create an iCTV. In addition, a questionnaire concerning experience of the participating radiation oncologists was filled out. We calculated median volumes, encompassing volumes and common volumes of the GTV, iGTV, CTV and iCTV. In addition, the generalized conformity index ($C_{gen}$) and overall observer variation were calculated (value of 1 representing full agreement; 0 no agreement). Interobserver variation of 3DCT and 4DCT delineations were analysed and compared.

Results: For all delineated and created volumes, the results of the mean median volumes, encompassing volumes, common volumes and $C_{gen}$ over all four patients are presented in Table 1. The mean overall standard deviation (SD) (averaged over 4 patients) was 0.54 cm and 0.58 cm on 3DCT and 4DCT, respectively. The $C_{gen}$ was smaller for 4DCT, indicating larger variations in delineation on 4DCT. Typical differences in delineations between the seven observers are presented in Fig. 1. The radiation oncologists experienced the GTV and iGTV delineations in this study as difficult.

<table>
<thead>
<tr>
<th>Patient</th>
<th>GTV</th>
<th>CTV</th>
<th>iGTV</th>
<th>CTV</th>
<th>iCTV</th>
</tr>
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<tbody>
<tr>
<td>Patient 1</td>
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<td>19.2</td>
<td>20.8</td>
<td>19.6</td>
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<tr>
<td>Patient 2</td>
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<td>19.0</td>
<td>20.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Patient 3</td>
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<td>20.0</td>
<td>20.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Patient 4</td>
<td>18.5</td>
<td>20.0</td>
<td>20.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>

Conclusion: A considerable interobserver variation in delineation of pancreatic tumours was found, with a mean $C_{gen}$ of 0.46 for 3DCT (GTV) and 0.35 for 4DCT (iGTV). This indicates a large variation in interpretation of diagnostic CT images and 4DCT images. The limited experience of the observers with delineation as well as the poor contrast between pancreatic cancer and surrounding tissues on CT imaging may have contributed to these results. This should be improved, perhaps by using additional imaging.

PO-0711
Relating CT image heterogeneity to patient outcome in the SCOPE 1 oesophageal cancer trial
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Purpose or Objective: Heterogeneity is a well recognised feature of malignancy that has been associated with adverse tumour biology (1). There is also initial evidence that it may be a potential prognostic biomarker for oesophageal cancer (2). Using texture analysis, the purpose of this study is to investigate the relationship between CT image heterogeneity and patient outcome in the SCOPE 1 UK wide multi-centre clinical trial on oesophageal cancer.

Material and Methods: The planning CT images of 215 patients from the SCOPE 1 clinical trial were uploaded to the TexRAD texture analysis software package. The original GTV outlines from the trial were imported on to the relevant DICOM CT images for each patient. Outcome data from the trial (Overall survival (OS) and progression free survival (PFS)) was included for analysis. Texture analysis of the area within