Purpose: To quantify pancreatic head tumor rotation and deformation due to the respiration using 4DCT and fiducial markers.

Methods: This study included seventeen pancreatic head tumor patients who were treated with gated SBRT using Novalis system in our institution. Each patient had two 5-mm-long fiducial markers placed in pancreatic head approximately 2 cm apart for the gating treatment. All patients had 4DCT scans of 3mm-slice thickness using a CT scanner (SENSATION, SIEMENS) under free breathing condition to create the internal target volume (ITV). The respiratory curve was generated through a pressure sensor placed on the patient’s abdomen. The 4DCT image data sets were binned into 8 phases: 0%inhale (end of exhale), 25%inhale, 50%inhale, 75% inhale, 100%inhale (end of inhale), 75%exhale, 50%exhale, and 25%exhale. The fiducial markers were contoured on each phase of 4DCT images, and the 3D coordinates (x,y,z) of centroid of the fiducial marker were recorded. The distance between two markers was calculated for each phase, and its variation on eight phases indicated the pancreatic head deformation. The orientation change of the two markers on eight phases indicated the pancreatic head rotation. Student t-test was performed for the statistical analysis.

Results: Pancreatic head rotation and deformation were observed through the breathing cycle. The largest rotation and deformation happened to the course from 0%inhale to 100%inhale. The rotation was 8.0±6.2 degree ranging from 2 to 20 degree. The deformation was 2.0±2.4 mm ranging from 0 to 6.6 mm. Both were statistically significant with p<10-4 for rotation and p=0.0033 for deformation.

Conclusions: The 4DCT images showed significant pancreatic head rotation and deformation due to respiration, and both rotation and deformation were highly variable between patients. For patients receiving SBRT with tight margin, rotation and deformation need to be considered, and individualized margin may be necessary.