University Medical Center Groningen 留学記 (2015/01/20 – 2015/03/20)
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1. Staying at Groningen
It had been a special time for me to stay at Groningen of the Netherlands, because that was my first time to visit Europe
and there was beautiful town just like European Gothic architectures, whose climate had been cold raining a lot of the
day in my visiting however it had been warmer than usual winter. My staying apartment, which was a share-house with
two Japanese roommates, was far away from University Medical Center Groningen (UMCG), so that I had walked to
school taking 45 minutes until getting a bicycle. Once getting bicycle as you imagine typical Dutch people, it only took
15 minutes for going to school. That was true that Holland is for the country of bicycle. It was a comfortable place for
bicycle thanks to flat road. Moreover, UMCG was also beautiful place as if usual Japanese hospitals were to be dim; it
was like a shopping mall where the patients could be exhilarated and would get vigorous soon.

2. Research at UMCG
My research theme of there was mainly intensity modulated proton therapy (IMPT). At first we this project team focused
on the breath-hold technique for IMPT, however as the study progresses, we were interested in the optimization
methods. We had three typical optimization techniques: a) IMPT with CTV-based robust optimization, b) IMPT with
PTV-based optimization, and c) single field uniformed dose (SFUD) with PTV-based optimization. Happily we could
use Raystation® 4.5 of Raysearch Laboratories planning machine, so we utilized this software for our research. a) is a
method for the optimization target at CTV region expansion shrinking with the margin assuming respiratory motion and
set-up error. b) and c) are methods for targeting the PTV, which is only 5 mm expansion of ICTV, therefore method a)
can make more OAR spare and more target focus.

Figure 1. Grote Markt in front of City-hall (right-side) and the main entrance of UMCG (left-side).
UMCG scheduled first proton therapy with IMPT for 2017, and have had interested in the robust optimization method. What we call ROBUST is against continuous density changes caused by respiratory motion because proton unlike photon is vulnerable to the density changes thereby increasing uncertainty. Moreover the modulation of beam intensity might cause more error, so that we had to investigate how this method was robust and credible. 4D dose recalculated by eight phases 4DCT can represent well respiratory continuous density change. Also interplay density changes between organ motion and beams are also recalculated. As a result, a) is a robust optimized method to the CTV if continuous respiratory density changes and strong intensity modulation affected it.
Figure 3. Planning in Raystation®. As you can see here, we can make sure as evaluation dose distribution assuming respiratory motion based on 4DCT: as a result, DVH shift and clinical goals shift can be evaluated. This respiratory dose evaluation (4D dose) can include the interplay effect as scanning density error.
3. Acknowledgement

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