# Comparison of daily plan adaptation strategies on a cohort of pancreatic cancer patients treated with SBRT

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## Introduction

Daily anatomical variations are commonly observed in locally advanced pancreatic cancer (LAPC) patients treated with SBRT, which consequently cause dosimetric uncertainties during the treatment course. Despite using a non-coplanar beam setup and real-time tumor tracking when delivering our SBRT treatments, it remains difficult to avoid that daily organs-at-risk (OAR) receive more dose than desired on the treatment day.

To cope with this challenge, daily plan adaptation is being explored as potential option for these patients. Plan adaptation, though, can be implemented in different ways, and it is not yet clear what is the gain from each strategy on LAPC patients, considering the available resources and logistics behind their implementation in the clinic.

## Aim

The current study explores and compares the effectiveness and efficiency of two adaptive strategies suitable for pancreatic cancer treated with SBRT: Full replanning vs. target realignment.

## Data available and clinical protocol

A total of 133 CT were collected from 35 LAPC patients, consisting of 35 planning CT (pCT) and 98 daily pre-treatment scans (preCT).

Treatment plans were computed using VOLO™ available in Precision® 2.01.1 (Accuray Inc, Sunnyvale, USA): Prescribed dose of 40Gy (isodose 80%). PTV coverage could be compromised to satisfy OAR dose-constraints on the stomach, duodenum and bowel (V35Gy<0.5cc).

## Plan adaptation strategies

Adaptive strategies experiments were conducted on the daily scans selected for plan adaptation, i.e. plans exceeding dose-constraints after rigidly transferring planned doses on daily scans.

The strategies being explored for daily plan adaptation were:

1) Full replaning without further parameter optimization tweaking: In Precision®, it is possible to create patient-specific templates containing the optimization parameters used in the pCT. These templates were used to perform a full inverse planning with new segments and new nodes according to the daily OARs. No further parameter optimization was applied.
2) Target realignment optimization by relocating the robot isocenter: Shifts on the planned dose distributions were optimized by minimizing OAR V35Gy dose-volumes while maximizing PTV coverage within a limited geometrical search space from -5 to 5mm in all directions.

## Plan adaptation strategies effect

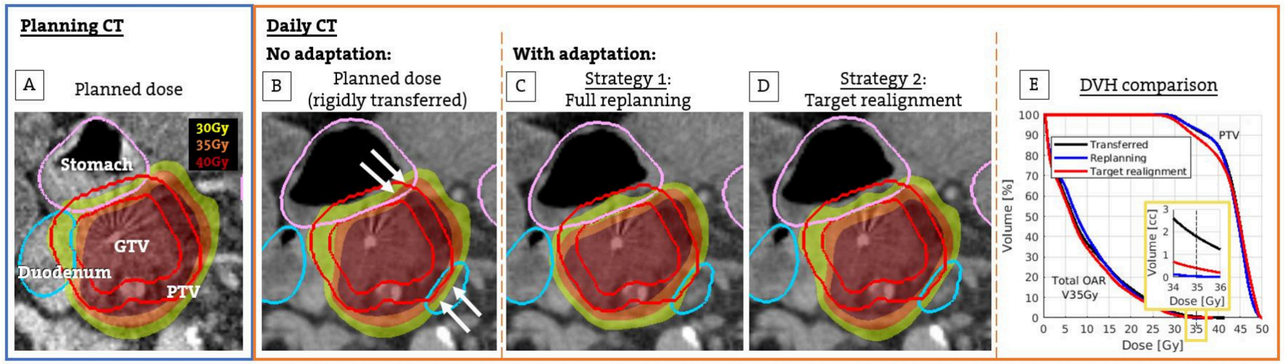
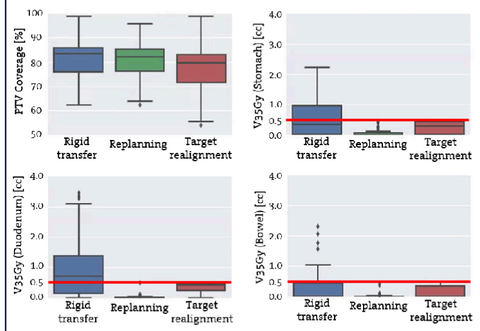



**Figure 1:** *Example case of a patient daily scan depicting the differences in dose distribution after transferring planned doses, full replanning and target realignment (B-D) vs. pCT situation (A). DVH comparison plot for the three mentioned options in relative volumes, and zoomed in (in the yellow box) with absolute volumes for V35Gy comparative purposes (E).*

## Dosimetric comparison in fractions where both strategies worked




| | Rigidly transferred | Full replanning | Target realignment |
|---|---|---|---|
| PTV Coverage [%] | 83 (76-86) | 82 (76-85) | 80 (71-83) |
| PTV V98% [Gy] | 27 (26-28) | 27 (25-28) | 24 (22-26) |
| GTV Coverage [%] | 95 (90-98) | 95 (91-97) | 94 (87-96) |
| Stomach V35Gy [cc] | 0.3 (0.0-0.9) | 0.0 (0.0-0.1) | 0.3 (0.0-0.4) |
| Duodenum V35Gy [cc] | 0.7 (0.1-1.4) | 0.0 (0.0-0.0) | 0.4 (0.2-0.4) |
| Bowel V35Gy [cc] | 0.0 (0.0-0.4) | 0.0 (0.0-0.0) | 0.0 (0.0-0.3) |

**Figure2, Table 1**: *Both strategies found an optimal solution in 64/70 daily scans that exceeded dose-constraints after rigidly transferring planned doses on the preCT. For these scans, boxplots (left) and comparative table (right) show the differences in target coverage and in each OAR V35Gy between each strategy and against transferred doses. As depicted in table 1 with red and green boxes, both strategies managed to achieve clinical acceptable OAR doses without compromising much the target coverage.*

## Failing cases

| | Rigidly transferred | Full replanning | Target realignment |
|---|---|---|---|
| PTV Coverage [%] | 78 (70-79) | 74 (64-76) | 63 (59-68) |
| PTV V98% [Gy] | 25 (24-26) | 25 (24-27) | 15 (13-18) |
| GTV Coverage [%] | 91 (88-96) | 89 (84-91) | 81 (79-91) |
| Stomach V35Gy [cc] | 1.5 (0.0-3.4) | 0.0 (0.0-0.2) | 0.5 (0.2-0.7) |
| Duodenum V35Gy [cc] | 0.9 (0.6-2.6) | 0.0 (0.0-0.1) | 0.9 (0.4-1.8) |
| Bowel V35Gy [cc] | 0.1 (0.0-1.8) | 0.0 (0.0-0.0) | 0.4 (0.0-0.4) |

**Table 2:** *Comparative table of dosimetric measures collected on the 15/70 scans where target realignment failed. Here, full replanning shows a clear superiority in front of target realignment, which in most of cases cannot achieve OAR dose-constraints (green vs. red boxes).*

## Conclusions

Plan adaptation was required in 70/98 (71%) fractions in our cohort of LAPC patients.

Full replanning resulted in the best strategy to adapt daily plans. However, target realignment optimization also achieved clinical acceptable plans in most of fractions (in 55/70 - 79%).

In general, full replanning managed to maintain target coverage while further reducing the doses on the daily organs, and was successful in almost all fractions (in 65/70 - 93%).

In the 55/70 fractions where target realignment successfully found an optimal solution, resulting plans compromised target coverage to achieve OAR constraints, but on average at a small cost of 2% PTV coverage reduction compared to full replanning.

Based on these results, we believe that target realignment optimization can be a potential alternative for pancreatic plan adaptation, requiring less workload, time and clinical resources.

## Summary of results in all cohort

After rigid transferring of planned doses from pCT to preCT:

- Fractions exceeding dose-constraints: 70/98 (= 71%)
- Fractions not exceeding dose-constraints: 28/98 (= 29%)

In fractions eligible for plan adaptation: 70/98 (= 71%):

- After full replanning:
  - 65/70 (= 93%) met dose-constraints
  - Optimization time*: 10 ± 4 min (Min-max: 3 – 24 min)
- After target realignment:
  - 55/70 (= 79%) met dose-constraints
  - Optimization time*: < 1 min
  - Average shifts displacements were: 3 ± 2 mm (min-max: 1 – 7 mm)

In 64/70 fractions, an optimal solution in both strategies was found.

* Reported timings do not consider daily organs re-contouring times.

## Contact information

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