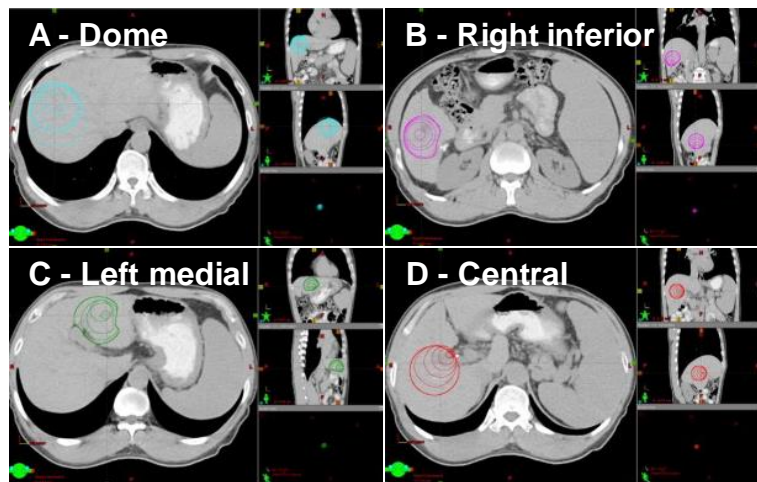


# Supplement A.



Position of target lesions evaluated in this study.

**Supplement B.** Constraint compliance at each location in the liver for the indicated sizes and modality. Darker shading signifies constraints not achievable. Numbers represent target diameter in cm.

| Proton            | Dome |   |   |   |   |   |   |   |   |    | Right inferior |   |   |   |   |   |   |   |   |    | Left medial |   |   |   |   |   |   |   |   |    | Central |   |   |   |   |   |   |   |   |    |   |   |
|-------------------|------|---|---|---|---|---|---|---|---|----|----------------|---|---|---|---|---|---|---|---|----|-------------|---|---|---|---|---|---|---|---|----|---------|---|---|---|---|---|---|---|---|----|---|---|
|                   | 1    | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1              | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1           | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1       | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |   |   |
| Liver - GTV       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗ |   |
| Duodenum          | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Small bowel       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Large bowel       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗ |   |
| Stomach           | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Esophagus         | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Heart/pericardium | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Skin              | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✗       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✗ | ✗ |
| Chest wall        | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✗       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✗ | ✗ |
| Photon            | Dome |   |   |   |   |   |   |   |   |    | Right inferior |   |   |   |   |   |   |   |   |    | Left medial |   |   |   |   |   |   |   |   |    | Central |   |   |   |   |   |   |   |   |    |   |   |
|                   | 1    | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1              | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1           | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1       | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |   |   |
| Liver - GTV       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✗ |   |
| Duodenum          | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗  | ✓       | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗  | ✗ |   |
| Small bowel       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Large bowel       | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗ |   |
| Stomach           | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Esophagus         | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Heart/pericardium | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓ |   |
| Skin              | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗ |   |
| Chest wall        | ✓    | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗  | ✓              | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ | ✗  | ✓           | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✗ | ✗  | ✓       | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗  | ✗ |   |

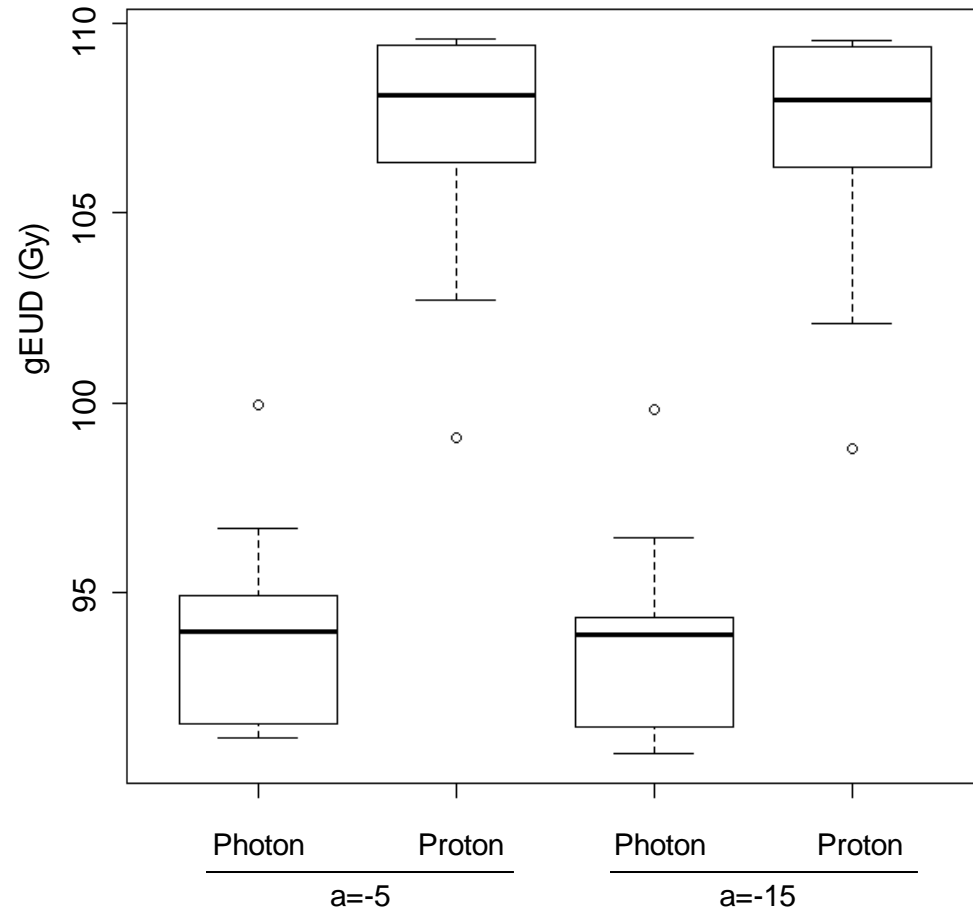
**Supplement C.** GTV coverage expressed in LQED2. Mean and median values for GTV coverage expressed in equivalent dose in 2 Gy fractions (LQED2). *p*-value represents comparison between photon and proton plans at each position across all sizes.

| Position       |                 | Dmean (Gy) |        | gEUD(-5) (Gy) |        | gEUD(-15) (Gy) |        | D95% (Gy) |        |
|----------------|-----------------|------------|--------|---------------|--------|----------------|--------|-----------|--------|
|                |                 | Photon     | Proton | Photon        | Proton | Photon         | Proton | Photon    | Proton |
| Dome           | Mean            | 94.3       | 107.0  | 94.1          | 106.9  | 93.8           | 106.7  | 91.2      | 104.5  |
|                | Median          | 94.0       | 108.2  | 94.0          | 108.1  | 93.9           | 108.0  | 90.8      | 106.0  |
|                | <i>p</i> -value |            | < 0.01 |               | < 0.01 |                | < 0.01 |           | < 0.01 |
| Right inferior | Mean            | 97.8       | 101.8  | 97.3          | 101.4  | 96.6           | 99.9   | 92.4      | 97.2   |
|                | Median          | 97.3       | 106.2  | 96.9          | 105.7  | 96.3           | 103.7  | 92.6      | 98.7   |
|                | <i>p</i> -value |            | ns     |               | ns     |                | ns     |           | 0.1    |
| Left medial    | Mean            | 97.5       | 102.2  | 97.2          | 102.0  | 96.8           | 101.7  | 93.1      | 99.1   |
|                | Median          | 94.5       | 104.6  | 94.2          | 104.5  | 93.9           | 104.4  | 91.4      | 102.8  |
|                | <i>p</i> -value |            | < 0.01 |               | < 0.01 |                | < 0.01 |           | < 0.01 |
| Central        | Mean            | 96.2       | 103.7  | 95.8          | 103.6  | 95.3           | 103.4  | 91.7      | 101.4  |
|                | Median          | 96.6       | 107.6  | 96.3          | 107.5  | 95.8           | 107.4  | 91.7      | 104.7  |
|                | <i>p</i> -value |            | < 0.05 |               | < 0.01 |                | < 0.01 |           | < 0.01 |

# Supplement D. GTV dose at position A (dome) as a function of size.

|         | Dmean (Gy) |        | gEUD (a=-5) (Gy) |        | gEUD (a=-15) (Gy) |        | D95% (Gy) |        |
|---------|------------|--------|------------------|--------|-------------------|--------|-----------|--------|
|         | Photon     | Proton | Photon           | Proton | Photon            | Proton | Photon    | Proton |
| 1       | 56.2       | 65.7   | 56.2             | 65.6   | 56.2              | 65.6   | 55.9      | 64.7   |
| 2       | 56.6       | 65.5   | 56.6             | 65.4   | 56.5              | 65.3   | 55.7      | 63.7   |
| 3       | 54.8       | 65.5   | 54.7             | 65.5   | 54.6              | 65.4   | 53.4      | 64.0   |
| 4       | 55.0       | 65.8   | 54.9             | 65.8   | 54.9              | 65.7   | 53.6      | 64.6   |
| 5       | 56.8       | 65.7   | 56.7             | 65.7   | 56.6              | 65.7   | 55.1      | 64.8   |
| 6       | 58.1       | 64.3   | 58.0             | 64.3   | 57.9              | 64.3   | 56.1      | 63.5   |
| 7       | 60.0       | 64.1   | 60.0             | 64.1   | 59.9              | 64.0   | 58.4      | 62.5   |
| 8       | 55.8       | 63.9   | 55.7             | 63.8   | 55.4              | 63.7   | 53.1      | 62.0   |
| 9       | 55.0       | 61.9   | 54.8             | 61.6   | 54.5              | 61.3   | 51.9      | 59.2   |
| 10      | 57.3       | 59.6   | 57.0             | 59.5   | 56.5              | 59.3   | 53.8      | 57.7   |
| p-value | < 0.01     |        | < 0.01           |        | < 0.01            |        | < 0.01    |        |

## Supplement E.



GTV dose at position A (dome) in photon and proton plans with dose points converted to 2-Gy equivalent dose prior to applying the gEUD model.

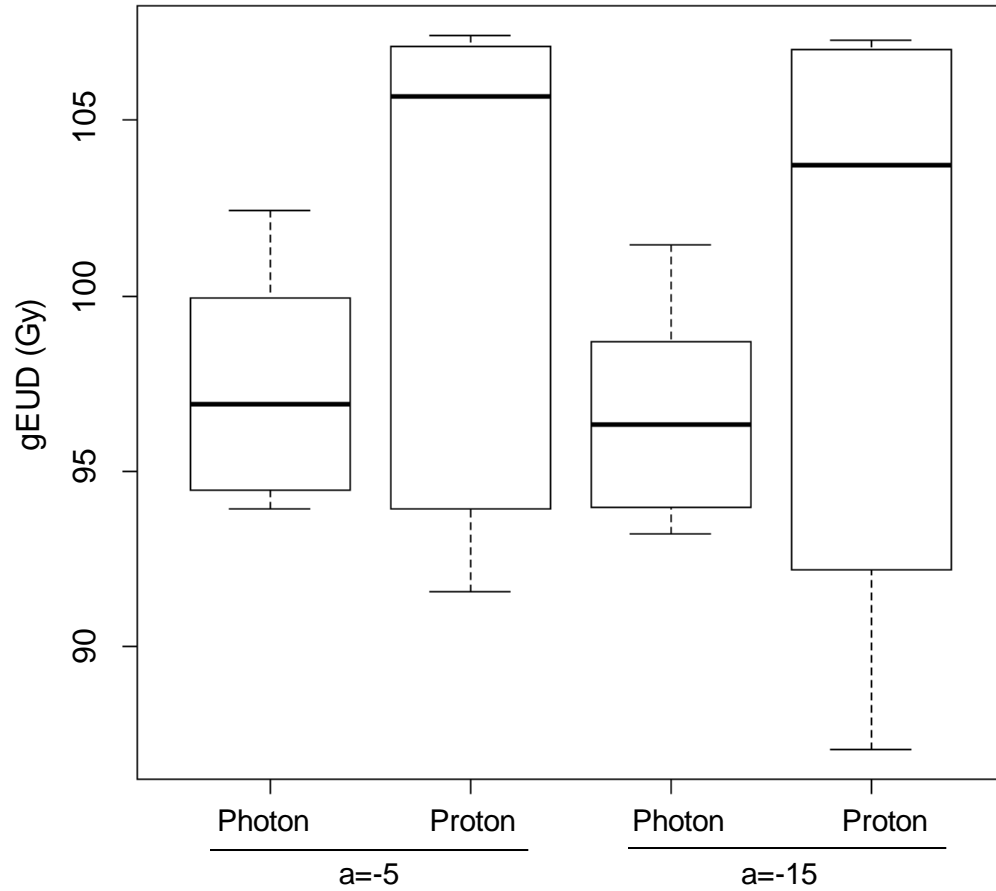
**Supplement F.** Liver sparing as function of target size at position A (dome). Evaluation of liver sparing based on target size in photon and proton plans.

| Size (cm) | V<15Gy (cm <sup>3</sup> ) |        | Mean liver dose (Gy) |        | Mean liver dose (LQED2) (Gy) |        | NTCP (%) |        |
|-----------|---------------------------|--------|----------------------|--------|------------------------------|--------|----------|--------|
|           | Photon                    | Proton | Photon               | Proton | Photon                       | Proton | Photon   | Proton |
| 1         | 1242                      | 1245   | 1.5                  | 1.0    | 4.0                          | 2.5    | 0.00     | 0.00   |
| 2         | 1173                      | 1200   | 4.0                  | 1.9    | 10.4                         | 4.8    | 0.00     | 0.00   |
| 3         | 1080                      | 1138   | 6.6                  | 3.1    | 17.1                         | 8.1    | 0.00     | 0.00   |
| 4         | 977                       | 1049   | 9.4                  | 6.8    | 24.4                         | 17.7   | 0.00     | 0.00   |
| 5         | 873                       | 977    | 12.3                 | 8.8    | 32.0                         | 23.0   | 0.02     | 0.00   |
| 6         | 801                       | 859    | 14.8                 | 11.7   | 38.5                         | 30.5   | 0.38     | 0.14   |
| 7         | 731                       | 843    | 15.7                 | 9.8    | 40.8                         | 25.5   | 0.80     | 0.00   |
| 8         | 675                       | 746    | 16.7                 | 11.2   | 43.4                         | 29.2   | 0.79     | 0.02   |
| 9         | 597                       | 696    | 17.8                 | 11.6   | 46.3                         | 30.2   | 0.94     | 0.02   |
| 10        | 518                       | 595    | 15.7                 | 13.5   | 40.8                         | 35.2   | 0.99     | 0.13   |
| p-value   | < 0.01                    |        | < 0.01               |        | <0.01                        |        | 0.0240   |        |

# Supplement G. GTV dose at position B (right inferior) as a function of size.

| Size (cm) | Dmean (Gy) |        | gEUD (a=-5) (Gy) |        | gEUD (a=-15) (Gy) |        | D95% (Gy) |        |
|-----------|------------|--------|------------------|--------|-------------------|--------|-----------|--------|
|           | Photon     | Proton | Photon           | Proton | Photon            | Proton | Photon    | Proton |
| 1         | 56.3       | 64.5   | 56.3             | 64.4   | 56.3              | 64.4   | 56.1      | 62.8   |
| 2         | 56.4       | 64.6   | 56.4             | 64.5   | 56.4              | 64.3   | 55.6      | 62.4   |
| 3         | 56.8       | 64.3   | 56.8             | 64.3   | 56.6              | 64.2   | 55.4      | 62.5   |
| 4         | 61.8       | 63.5   | 61.5             | 63.2   | 60.9              | 62.5   | 56.9      | 59.2   |
| 5         | 57.7       | 64.0   | 57.6             | 63.6   | 57.4              | 62.0   | 55.5      | 59.3   |
| 6         | 59.0       | 64.2   | 58.7             | 64.2   | 58.2              | 64.2   | 55.5      | 63.4   |
| 7         | 57.1       | 57.8   | 56.7             | 56.9   | 55.9              | 52.2   | 52.7      | 52.5   |
| 8         | 60.7       | 56.5   | 60.3             | 56.4   | 59.6              | 56.1   | 55.9      | 54.1   |
| 9         | 60.4       | 56.3   | 60.0             | 56.0   | 59.2              | 55.3   | 55.5      | 54.3   |
| 10        | 60.2       | 55.2   | 59.8             | 54.9   | 59.1              | 54.2   | 55.4      | 53.1   |
| p-value   | 0.19       |        | 0.18             |        | 0.28              |        | 0.050     |        |

## Supplement H.



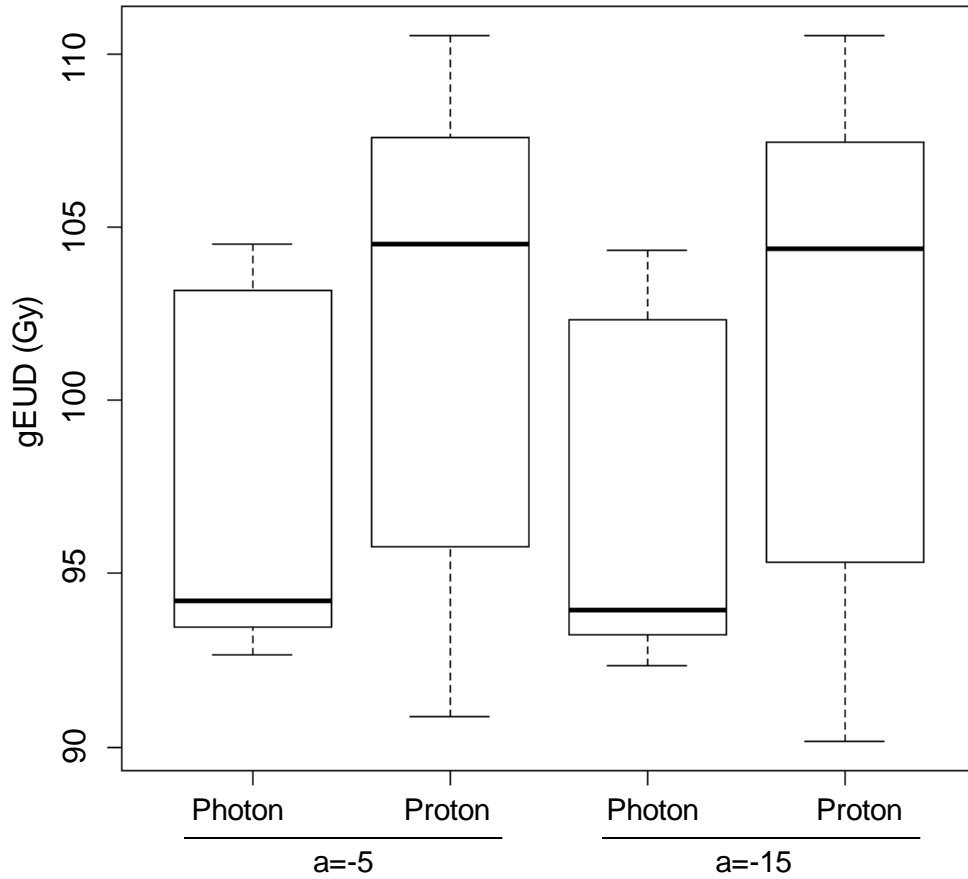
GTV dose at position B (right inferior) in photon and proton plans with dose points converted to 2-Gy equivalent dose prior to applying the gEUD model.



# Supplement I. GTV dose at position C (left medial) as a function of size.

|         | Dmean (Gy) |        | gEUD (a=-5) (Gy) |        | gEUD (a=-15) (Gy) |        | D95% (Gy) |        |
|---------|------------|--------|------------------|--------|-------------------|--------|-----------|--------|
|         | Photon     | Proton | Photon           | Proton | Photon            | Proton | Photon    | Proton |
| 1       | 62.7       | 66.4   | 62.7             | 66.3   | 62.6              | 66.3   | 61.1      | 65.2   |
| 2       | 62.8       | 64.7   | 62.7             | 64.6   | 62.5              | 64.5   | 60.1      | 62.8   |
| 3       | 62.2       | 64.6   | 61.9             | 64.6   | 61.4              | 64.5   | 57.7      | 63.1   |
| 4       | 59.5       | 64.4   | 59.1             | 64.3   | 58.5              | 64.3   | 55.2      | 63.1   |
| 5       | 56.2       | 62.5   | 56.1             | 62.5   | 56.1              | 62.4   | 55.0      | 61.4   |
| 6       | 56.1       | 63.0   | 56.0             | 63.0   | 56.0              | 62.9   | 54.7      | 62.0   |
| 7       | 57.1       | 59.0   | 56.9             | 59.0   | 56.6              | 58.8   | 54.7      | 57.4   |
| 8       | 56.3       | 56.1   | 56.2             | 55.9   | 55.9              | 55.5   | 53.3      | 53.1   |
| 9       | 55.7       | 54.8   | 55.6             | 54.5   | 55.4              | 54.1   | 53.2      | 51.9   |
| 10      | 56.2       | 57.6   | 56.1             | 57.5   | 55.8              | 57.2   | 53.4      | 55.0   |
| p-value | 0.01       |        | 0.01             |        | 0.01              |        | 0.005     |        |

## Supplement J.

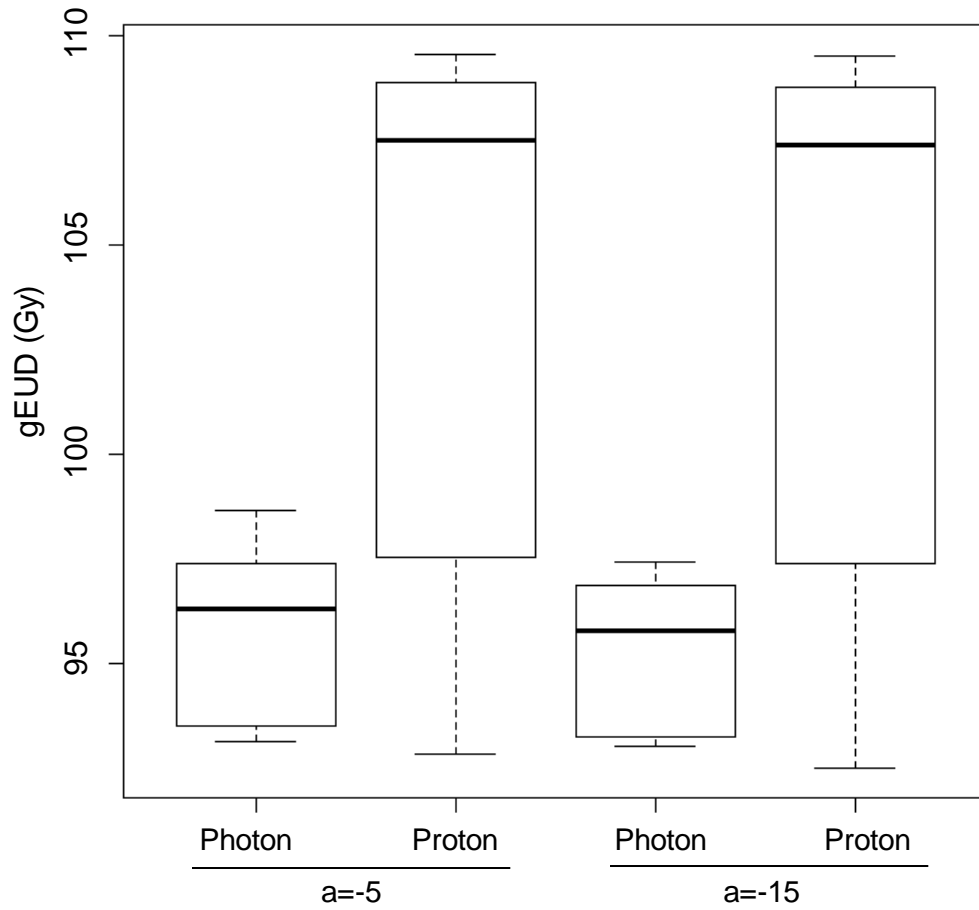


GTV dose at position C (left medial). GTV dose in photon and proton plans with dose points converted to 2-Gy equivalent dose prior to applying the gEUD model.

# Supplement K. GTV dose at position D (central) as a function of size.

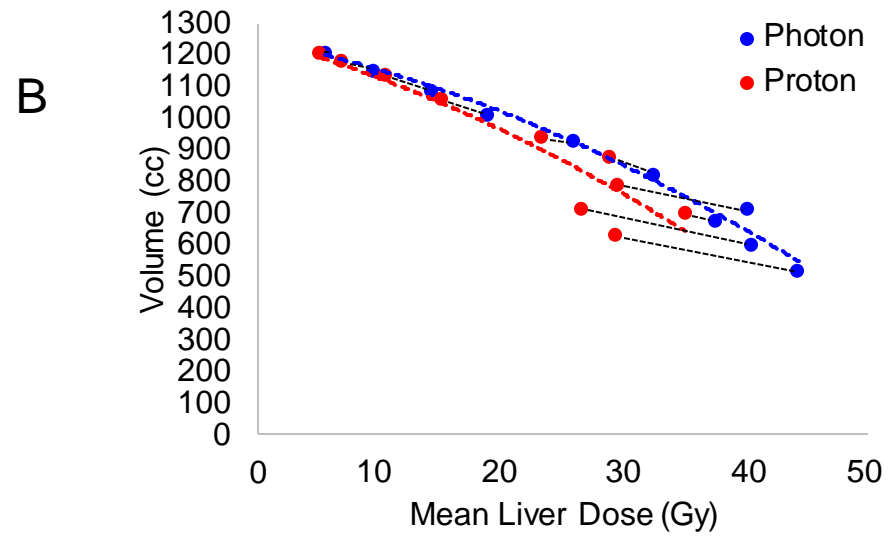
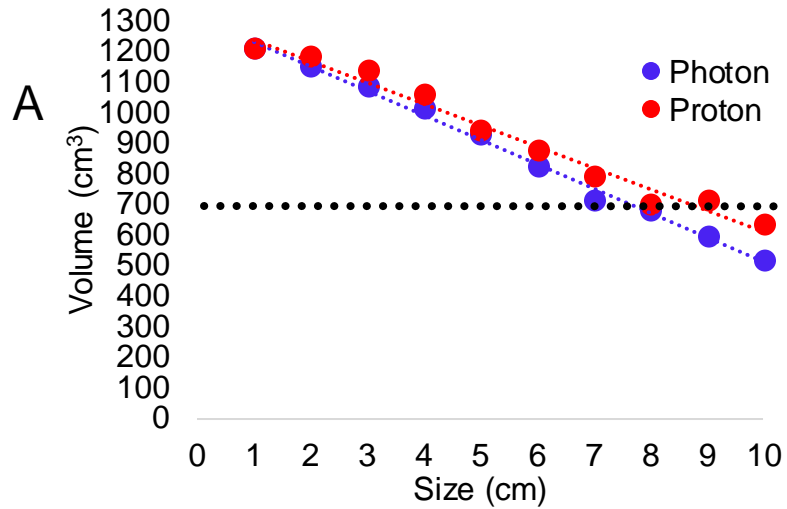
|         | Dmean (Gy) |        | gEUD (a=-5) (Gy) |        | gEUD (a=-15) (Gy) |        | D95% (Gy) |        |
|---------|------------|--------|------------------|--------|-------------------|--------|-----------|--------|
|         | Photon     | Proton | Photon           | Proton | Photon            | Proton | Photon    | Proton |
| 1       | 55.9       | 65.4   | 55.9             | 65.3   | 55.9              | 65.3   | 55.0      | 64.1   |
| 2       | 56.8       | 64.4   | 56.8             | 64.3   | 56.6              | 64.2   | 55.2      | 62.2   |
| 3       | 56.2       | 65.2   | 56.1             | 65.1   | 56.0              | 65.0   | 54.3      | 63.4   |
| 4       | 58.6       | 65.8   | 58.5             | 65.7   | 58.3              | 65.7   | 56.0      | 64.6   |
| 5       | 58.6       | 65.8   | 58.4             | 65.7   | 58.1              | 65.7   | 55.7      | 64.8   |
| 6       | 58.1       | 64.7   | 58.0             | 64.7   | 57.9              | 64.7   | 56.0      | 63.9   |
| 7       | 56.3       | 58.6   | 56.1             | 58.5   | 55.8              | 58.5   | 53.5      | 57.4   |
| 8       | 57.8       | 58.7   | 57.5             | 58.6   | 57.1              | 58.4   | 54.7      | 56.7   |
| 9       | 58.9       | 55.8   | 58.4             | 55.7   | 57.8              | 55.5   | 55.0      | 54.6   |
| 10      | 59.7       | 57.9   | 59.2             | 57.8   | 58.4              | 57.1   | 55.1      | 56.5   |
| p-value | 0.01       |        | 0.01             |        | 0.01              |        | 0.001     |        |

## Supplement L.



GTV dose at position D (central) in photon and proton plans with dose points converted to 2-Gy equivalent dose prior to applying the gEUD model.

# Supplement M.



Liver sparing in photon and proton plans at position B (right inferior).

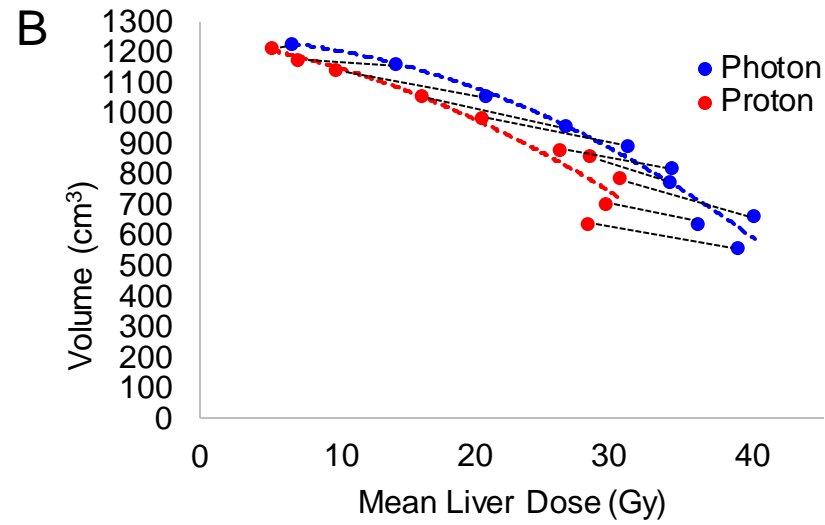
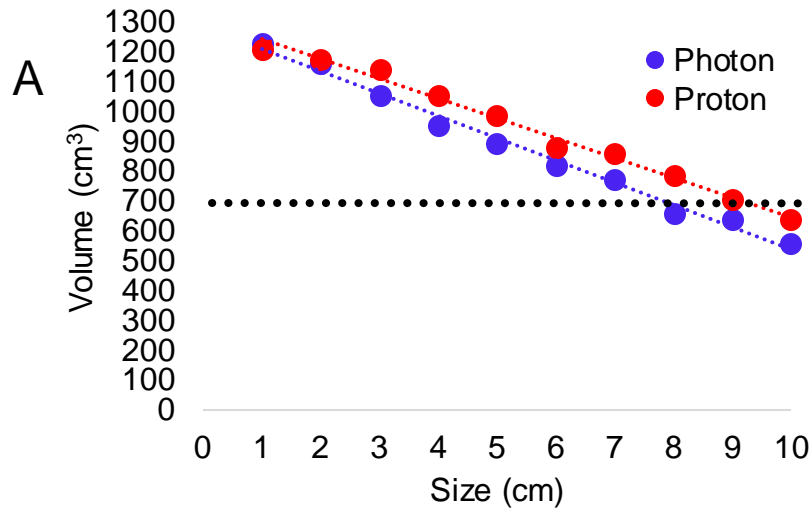
A. Liver volume receiving < 15 Gy. Dotted line represents constraint of 700 cc.

B. Comparison of volume spared and mean liver dose expressed in LQED2. Black dotted lines represent paired photon-proton plans per size. Colored dash lined represent trend.

**Supplement N.** Liver sparing in photon and proton plans at position B (right inferior). Evaluation of liver sparing based on target size in photon and proton plans.

| Size (cm)       | V<15Gy (cm <sup>3</sup> ) |        | Mean liver dose (Gy) |        | Mean liver dose (LQED2) (Gy) |        | NTCP (%) |        |
|-----------------|---------------------------|--------|----------------------|--------|------------------------------|--------|----------|--------|
|                 | Photon                    | Proton | Photon               | Proton | Photon                       | Proton | Photon   | Proton |
| 1               | 1211                      | 1212   | 2.1                  | 2.0    | 5.6                          | 5.2    | 0.00     | 0.00   |
| 2               | 1152                      | 1186   | 3.7                  | 2.7    | 9.6                          | 7.0    | 0.00     | 0.00   |
| 3               | 1088                      | 1141   | 5.5                  | 4.0    | 14.4                         | 10.5   | 0.00     | 0.00   |
| 4               | 1014                      | 1063   | 7.3                  | 5.8    | 18.9                         | 15.1   | 0.00     | 0.00   |
| 5               | 931                       | 947    | 10.0                 | 9.0    | 26.0                         | 23.4   | 0.00     | 0.00   |
| 6               | 826                       | 880    | 12.5                 | 11.1   | 32.6                         | 28.9   | 0.02     | 0.08   |
| 7               | 713                       | 794    | 15.5                 | 11.4   | 40.3                         | 29.5   | 0.41     | 0.03   |
| 8               | 681                       | 702    | 14.5                 | 13.5   | 37.6                         | 35.1   | 0.14     | 0.04   |
| 9               | 600                       | 714    | 15.6                 | 10.2   | 40.6                         | 26.6   | 0.27     | 0.01   |
| 10              | 519                       | 636    | 17.1                 | 11.3   | 44.4                         | 29.4   | 0.54     | 0.03   |
| <i>p</i> -value | 0.0020                    |        | 0.0061               |        | 0.0061                       |        | 0.088    |        |

# Supplement O.



Liver sparing in photon and proton plans at position C (left medial).

A. Liver volume receiving < 15 Gy. Dotted line represents constraint of 700 cc.

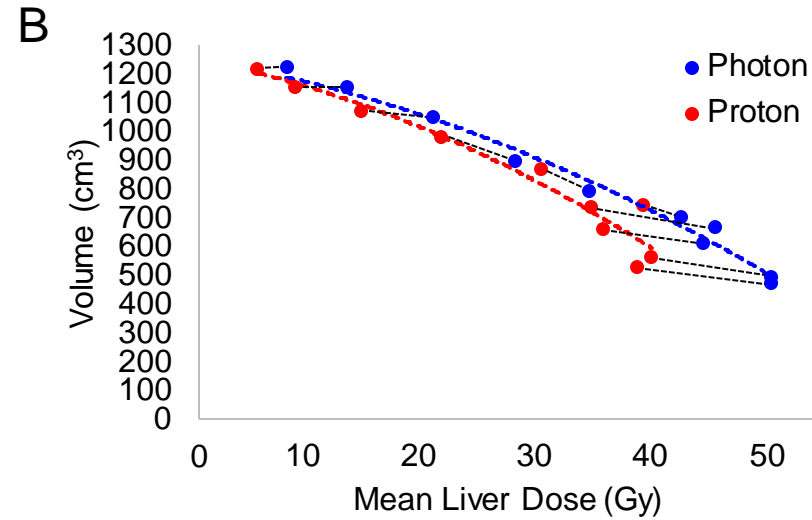
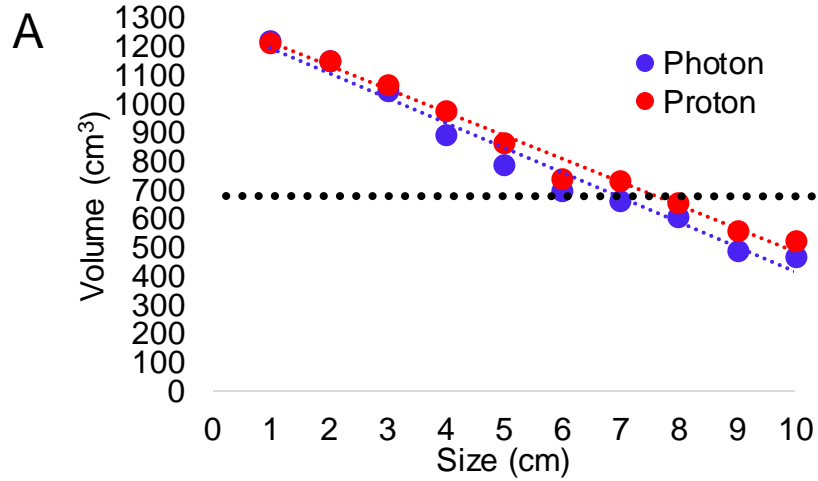
B. Comparison of volume spared and mean liver dose expressed in LQED2. Black dotted lines represent paired photon-proton plans per size. Colored dash lined represent trend.

**Supplement P.** Liver sparing in photon and proton plans at position C (left medial). Evaluation of liver sparing based on target size in photon and proton plans.

| Size (cm)       | V<15Gy (cm <sup>3</sup> ) |        | Mean liver dose (Gy) |        | Mean liver dose (LQED2) (Gy) |        | NTCP (%) |        |
|-----------------|---------------------------|--------|----------------------|--------|------------------------------|--------|----------|--------|
|                 | Photon                    | Proton | Photon               | Proton | Photon                       | Proton | Photon   | Proton |
| 1               | 1229                      | 1215   | 2.6                  | 2.0    | 6.8                          | 5.3    | 0.00     | 0.00   |
| 2               | 1163                      | 1179   | 5.5                  | 2.8    | 14.2                         | 7.2    | 0.00     | 0.00   |
| 3               | 1059                      | 1144   | 8.0                  | 3.8    | 20.7                         | 9.9    | 0.00     | 0.00   |
| 4               | 959                       | 1057   | 10.2                 | 6.2    | 26.4                         | 16.1   | 0.00     | 0.00   |
| 5               | 897                       | 989    | 11.9                 | 7.8    | 30.9                         | 20.4   | 0.00     | 0.00   |
| 6               | 820                       | 884    | 13.1                 | 10.0   | 34.1                         | 26.0   | 0.01     | 0.00   |
| 7               | 776                       | 862    | 13.1                 | 10.9   | 34.0                         | 28.2   | 0.01     | 0.00   |
| 8               | 662                       | 786    | 15.4                 | 11.7   | 40.0                         | 30.4   | 0.09     | 0.00   |
| 9               | 641                       | 707    | 13.9                 | 11.3   | 36.0                         | 29.3   | 0.02     | 0.00   |
| 10              | 561                       | 641    | 14.9                 | 10.8   | 38.8                         | 28.0   | 0.07     | 0.00   |
| <i>p</i> -value | 0.00040                   |        | 0.00001              |        | 0.00001                      |        | 0.101    |        |



# Supplement Q.



Liver sparing in photon and proton plans at position D (central).

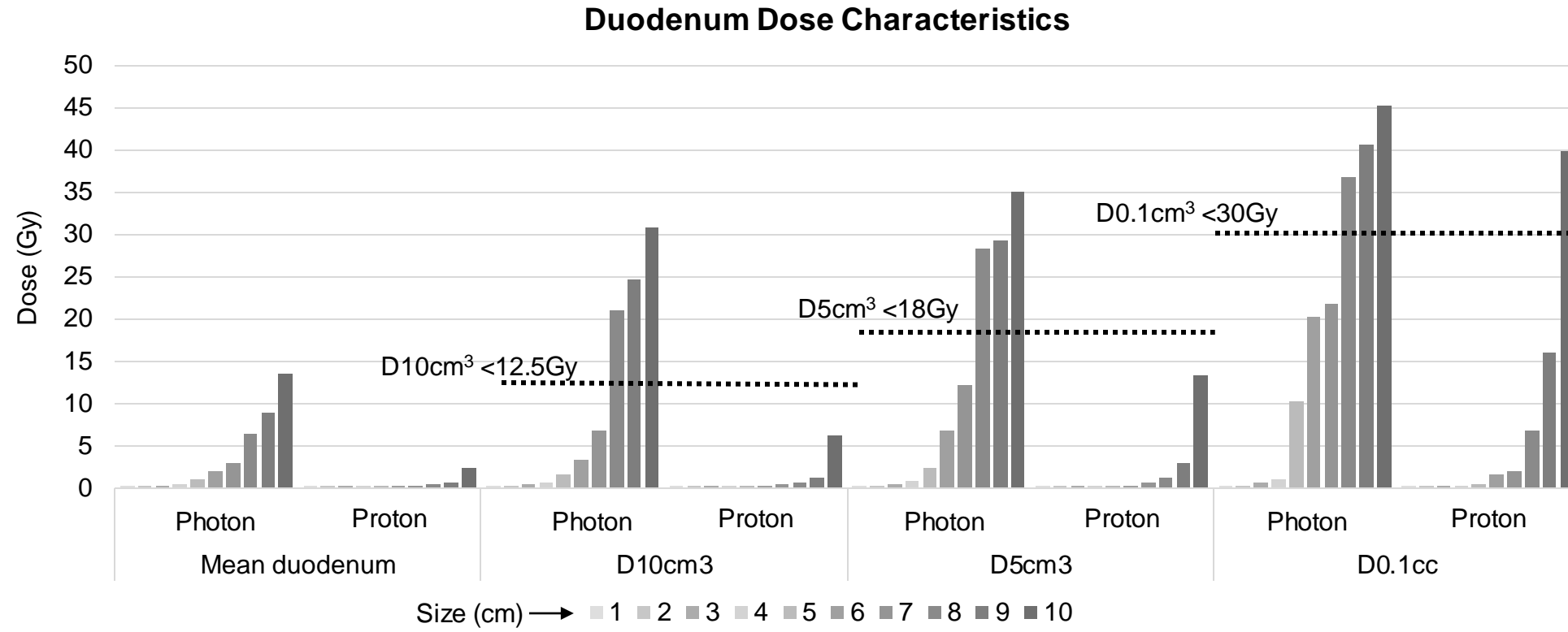
A. Liver volume receiving < 15 Gy. Dotted line represents constraint of 700 cc.

B. Comparison of volume spared and mean liver dose expressed in LQED2. Black dotted lines represent paired photon-proton plans per size. Colored dash lined represent trend.

**Supplement R.** Liver sparing in photon and proton plans at position D (central). Evaluation of liver sparing based on target size in photon and proton plans.

|         | V<15Gy (cm3) |        | Mean liver dose (Gy) |        | Mean liver dose (LQED2) (Gy) |        | NTCP (%) |        |
|---------|--------------|--------|----------------------|--------|------------------------------|--------|----------|--------|
|         | Photon       | Proton | Photon               | Proton | Photon                       | Proton | Photon   | Proton |
| 1       | 1227         | 1219   | 3.0                  | 2.0    | 7.8                          | 5.3    | 0.00     | 0.00   |
| 2       | 1159         | 1156   | 5.1                  | 3.4    | 13.3                         | 8.7    | 0.00     | 0.00   |
| 3       | 1049         | 1074   | 8.0                  | 5.6    | 20.9                         | 14.6   | 0.00     | 0.00   |
| 4       | 900          | 981    | 10.9                 | 8.3    | 28.3                         | 21.7   | 0.00     | 0.00   |
| 5       | 796          | 872    | 13.4                 | 11.7   | 34.9                         | 30.5   | 0.02     | 0.06   |
| 6       | 703          | 745    | 16.6                 | 15.3   | 43.1                         | 39.7   | 0.33     | 0.07   |
| 7       | 669          | 736    | 17.7                 | 13.5   | 46.1                         | 35.0   | 0.71     | 0.19   |
| 8       | 613          | 659    | 17.4                 | 13.9   | 45.1                         | 36.2   | 0.69     | 0.30   |
| 9       | 498          | 562    | 19.7                 | 15.6   | 51.2                         | 40.5   | 0.97     | 0.71   |
| 10      | 472          | 528    | 19.7                 | 15.1   | 51.1                         | 39.2   | 0.97     | 0.68   |
| p-value | 0.00140      |        | 0.00011              |        | 0.00011                      |        | 0.027    |        |

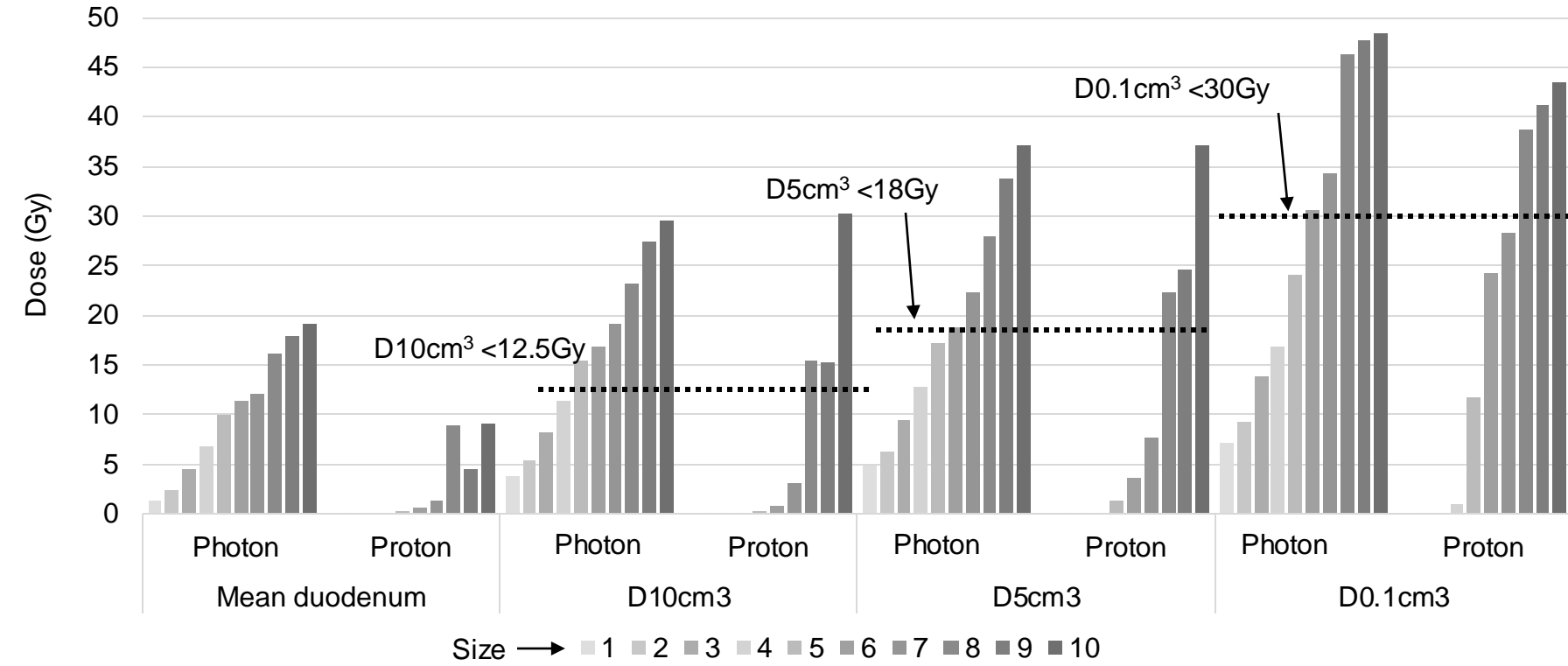
# Supplement S.



Evaluation of duodenal dose sparing with prescribed constraints noted at position A (dome).

# Supplement T.

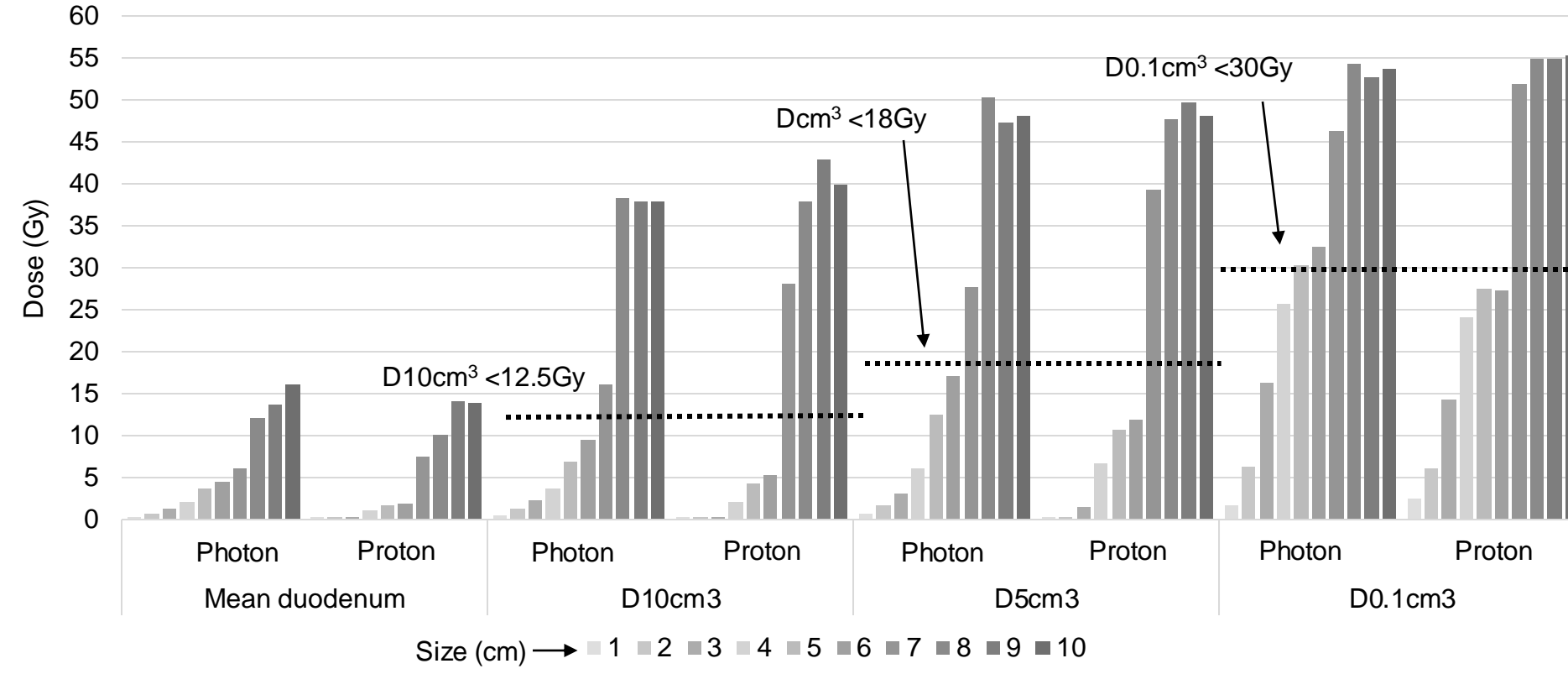
## Duodenum Dose Characteristics



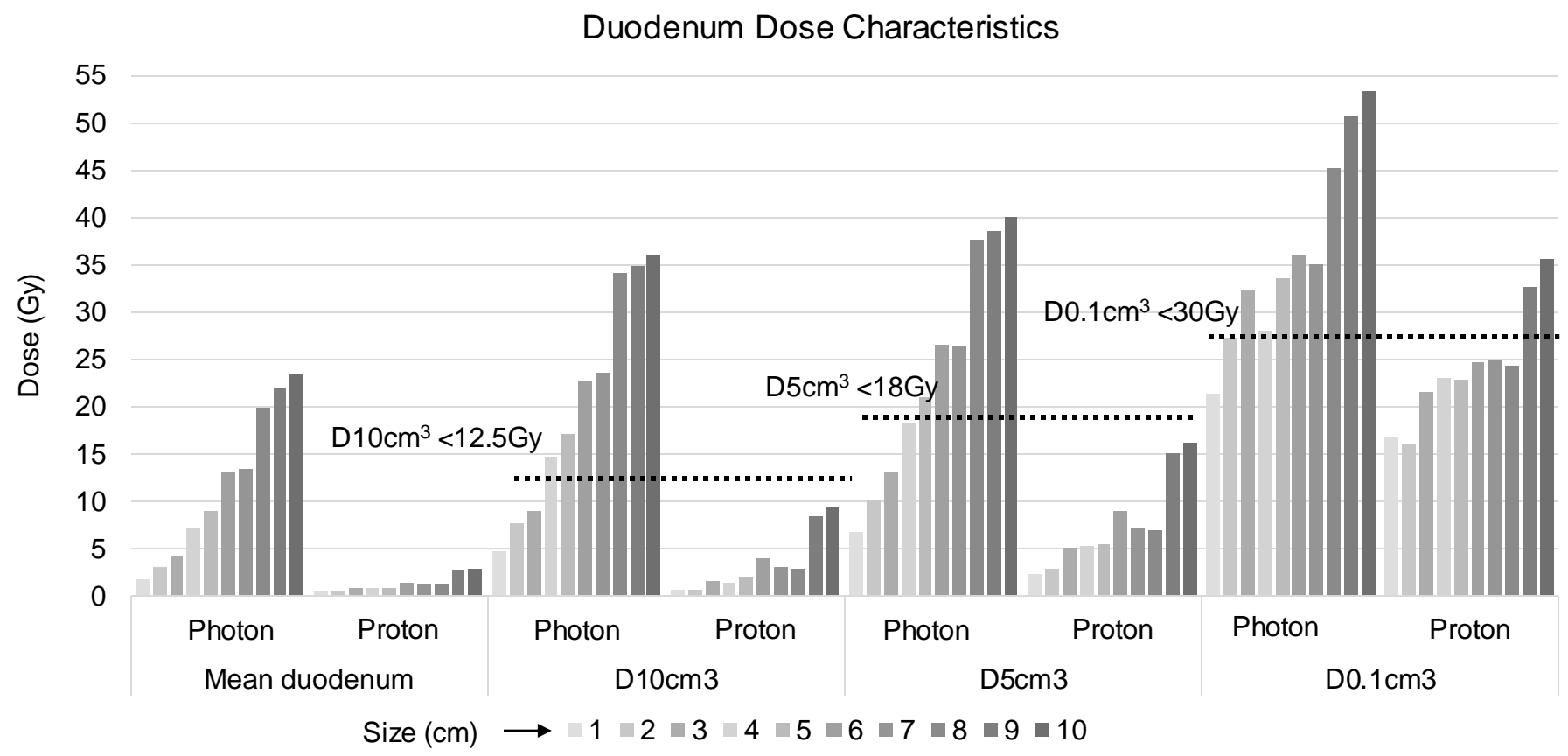
Evaluation of duodenal dose sparing with prescribed constraints noted at position B (right inferior).

# Supplement U.

## Duodenum Dose Characteristics



Evaluation of duodenal dose sparing with prescribed constraints noted at position C (left medial).



Evaluation of duodenal dose sparing with prescribed constraints noted at position D (central).