

# Evaluation of Lung Dose Reduction in VMAT Treatment Plans for Esophageal Cancer: A Comparative Study of Avoidance Strategies

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## INTRODUCTION

• This study aims to evaluate the utility through comparison of three treatment plans: Full Arc-Avoidance Sector (FA-AS), Full Arc-Avoidance Structure (FA-ST), and Partial Arc (PA), and differentiated by the same avoidance angle, in order to reduce lung dose.

• The evaluation will be conducted by comparing lung doses, low-dose distribution, total MU, and other parameters, using Volumetric-Modulated Arc Therapy (VMAT) treatment plans for esophageal cancer patients.

## METHODS & MATERIALS

• The PTVs of 10 esophageal cancer patients treated at our institution were transferred to the ATOM Phantom images. All treatment plans were executed using the Acuros XB algorithm in the Eclipse Treatment Planning System (Version 16.1).

• The plan aimed for 66Gy in 33 fractions. The treatment plans were categorized into three methods by restricting the incident beams in the range of 240° to 300° and 60° to 120°. The treatment plan was designed with Halcyon treatment machine.

• In the FA-AS, we generated 4 arcs with gantry angles of 181° to 179° and set Avoidance Sectors in the range of 240° to 300° and 60° to 120°, ensuring beam off during these intervals(Fig. 1).

• The FA-ST involved creating a ring-shaped structure with a diameter of 15 cm and a thickness of 5mm at the center of the ATOM Phantom images, matching the SI range of each PTV. Avoidance Structures were generated using only the portions corresponding to gantry angles of 240° to 300° and 60° to 120°. 4 arcs with gantry angles of 181° to 179° were created, applying Entry Mode to the Avoidance Structure.

• The PA generated a total of 12 arcs (4 arcs each for gantry angles 181° to 240°, 300° to 60°, and 120° to 179°) to apply the same control points as other methods based on a Full Arc approach.

## METHODS & MATERIALS

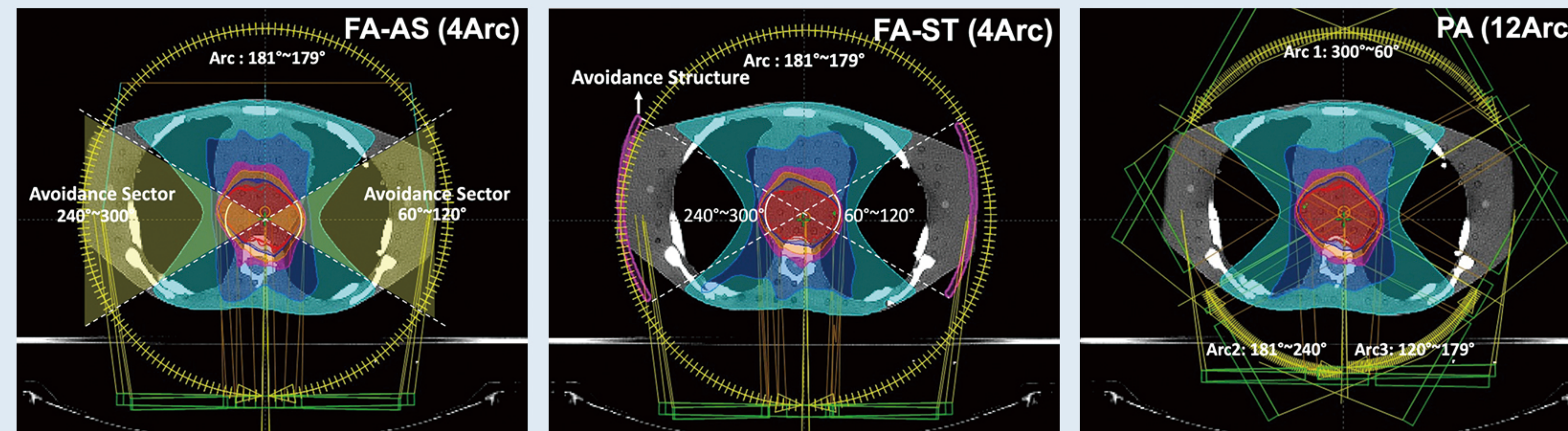


Fig. 1. Configuration example of FA-AS, FA-ST, PA

• For PTV evaluation, we utilized Homogeneity Index (H.I) and Conformity Index (C.I). Evaluation of Organs at Risk (OAR) included  $D_{mean}$  of heart and  $D_{mean}$ ,  $V_{5Gy}$  of both lung. For low dose region assessment, the 50% Isodose Volume of the prescribed dose was compared.

• Treatment plan efficiency was evaluated by comparing total MU and Beam On Time. Differences were assessed for statistical significance ( $P < 0.05$ ) by use of One-way ANOVA.

## RESULTS

• FA-ST demonstrated superior results in PTV H.I and mean lung dose but exhibited similar outcomes to the FA-AS ( $P > 0.05$ )(Table 1).

• Both FA-AS and FA-ST outperformed PA in mean lung dose reduction by approximately 4% ( $P < 0.001$ )(Fig. 2).

• FA-AS can reduce total MU by 41.3% ( $P < 0.001$ ) and 50% Isodose Volume by 1.7% ( $P < 0.05$ ) compared to FA-ST.

Parameters		FA-AS	FA-ST	PA	P-value		
		Mean	Mean	Mean	FA-AS vs. FA-ST	FA-AS vs. PA	FA-ST vs. PA
PTV	H.I	1.06	1.05	1.07	<0.001	<0.001	<0.001
	C.I	0.97	0.96	0.98	0.065	0.04	<0.001
Heart	$D_{mean}$ (cGy)	3558.1	3576.6	3398.1	0.729	0.003	0.003
	$V_{5Gy}$ (%)	69.3	69.7	72	0.471	<0.001	<0.001
Lung	$D_{mean}$ (cGy)	1549.7	1542.3	1607.4	0.479	<0.001	<0.001
	50% Isodose Volume (cc)	1834.8	1868	1736.3	0.023	<0.001	<0.001
Total MU		641	1093	603	<0.001	<0.001	<0.001
Beam On Time (sec)		151.3	146.6	167.8	<0.001	<0.001	<0.001

Table 1. Results of each evaluation criterion

## DISCUSSION

• For FA-ST, a structure is created to restrict the entry beam, and an Entry Mode is applied to this structure to block the beam through the MLC. This results in the formation of numerous beamlets, and the beam delivery continues even when the MLC is closed in the specified structure area, leading to an increase in MU.

• For FA-AS, radiation is blocked by defining the range of the area where the entry beam is restricted, and within this defined range, the delivery of radiation stops regardless of the position of the MLC. This can reduce total MU and particularly decrease the occurrence of side effects such as radiation pneumonitis by reducing the Lung  $V_{5Gy}$  area.

## CONCLUSION

• For esophageal cancer VMAT, adopting FA-AS is recommended due to its simplicity, significant reduction in total MU, and a lung dose reduction similar to that of FA-ST.

• These findings emphasize the importance of selecting an optimal avoidance technique to enhance treatment efficiency and minimize radiation-induced side effects.

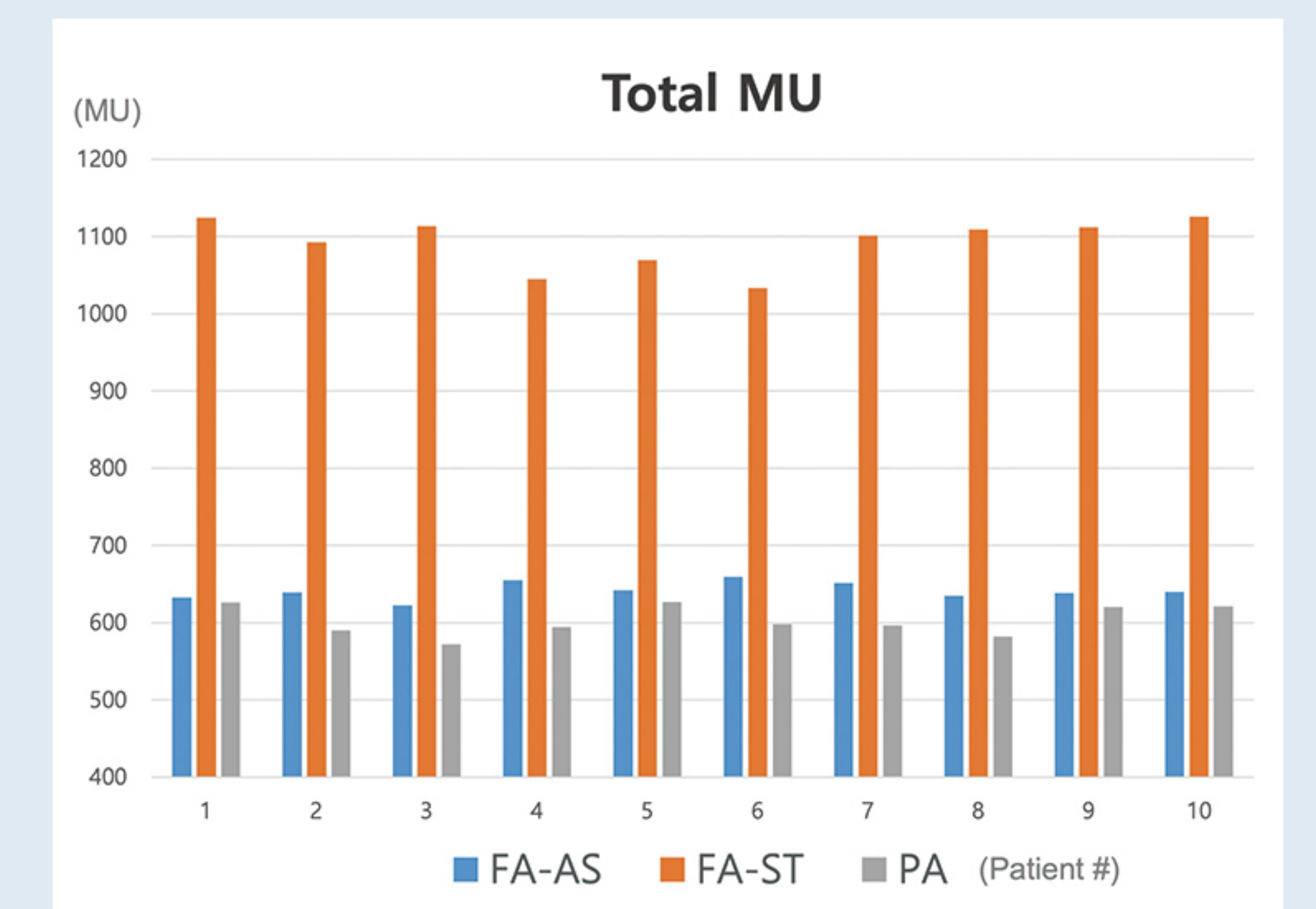
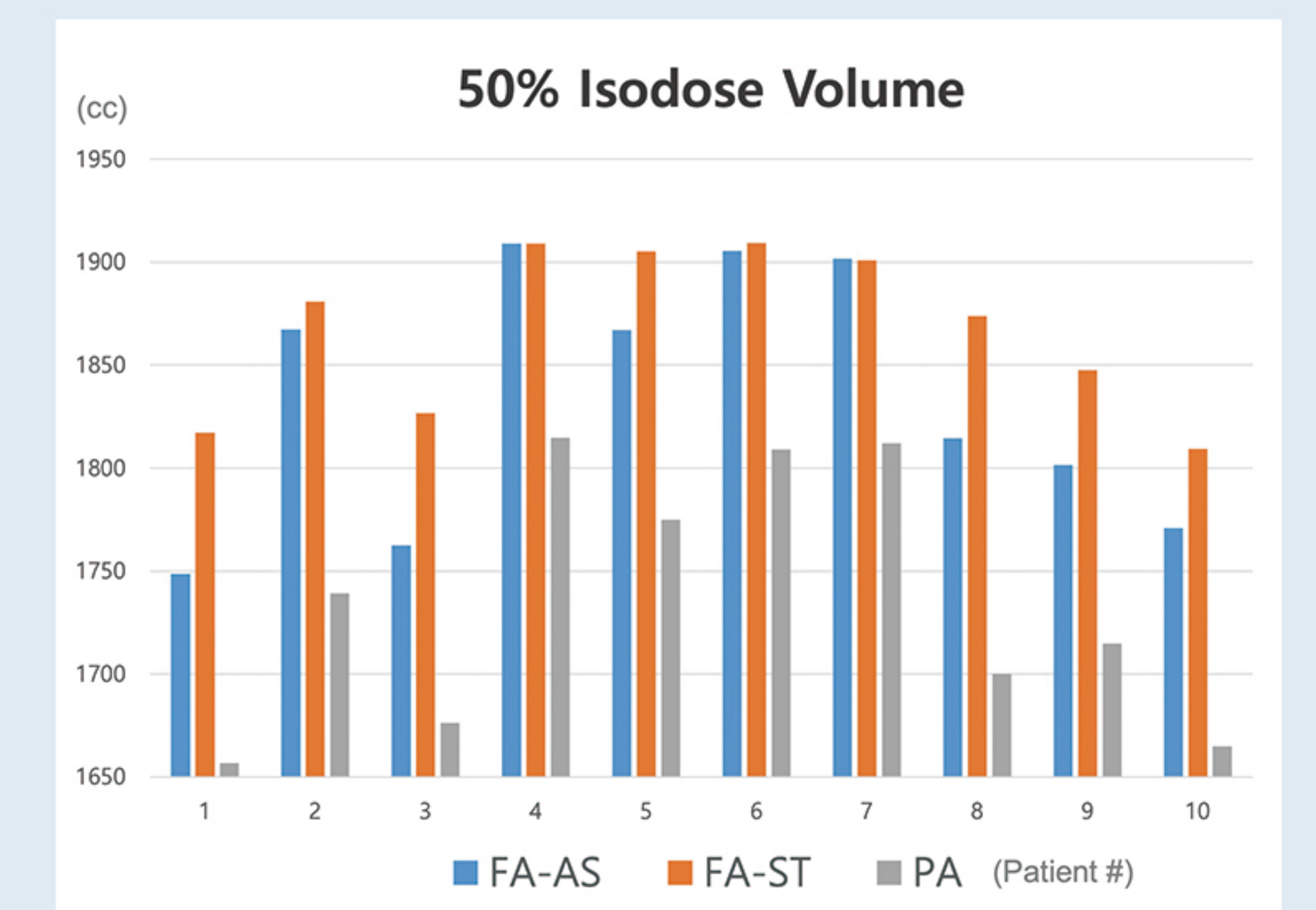
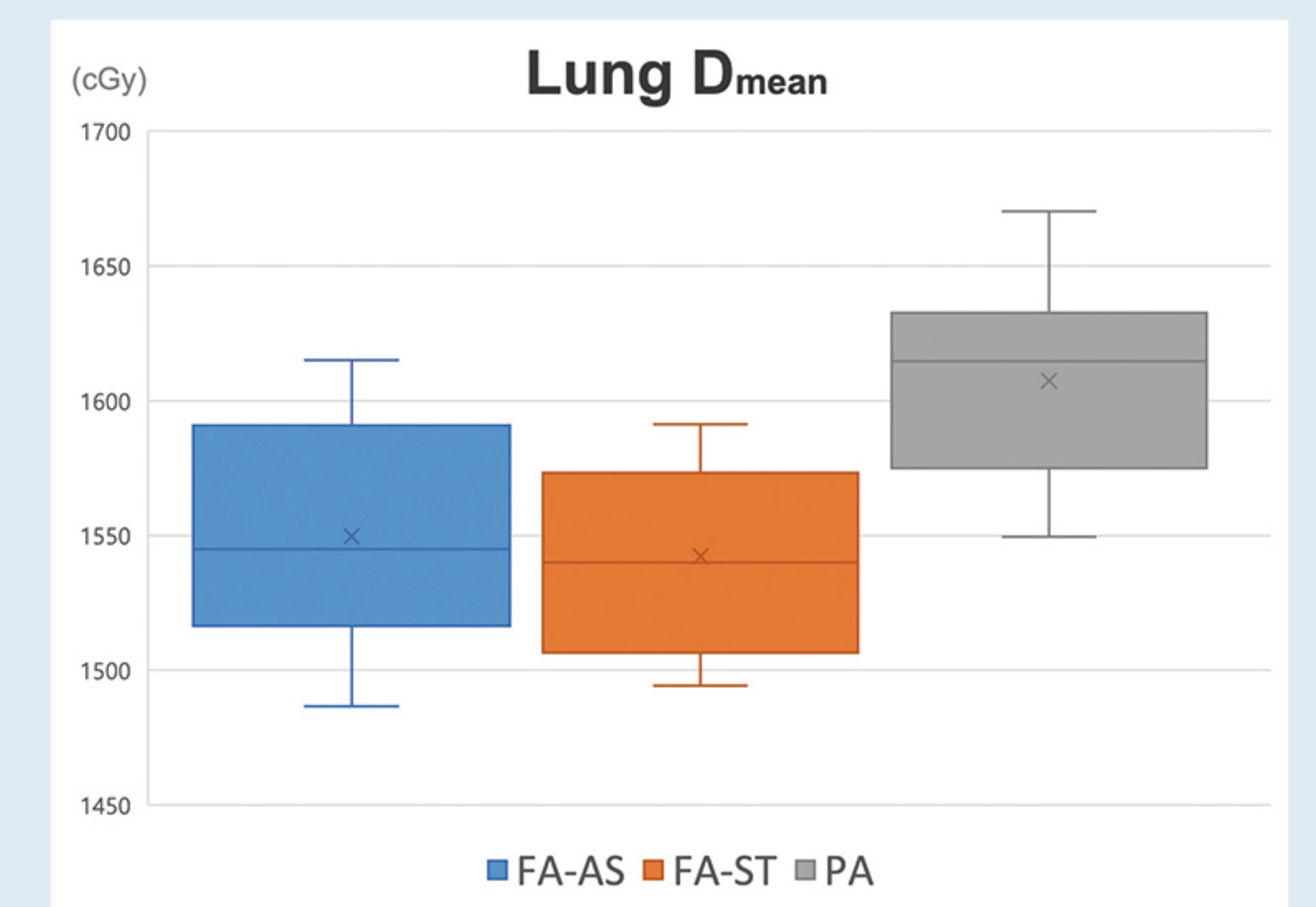
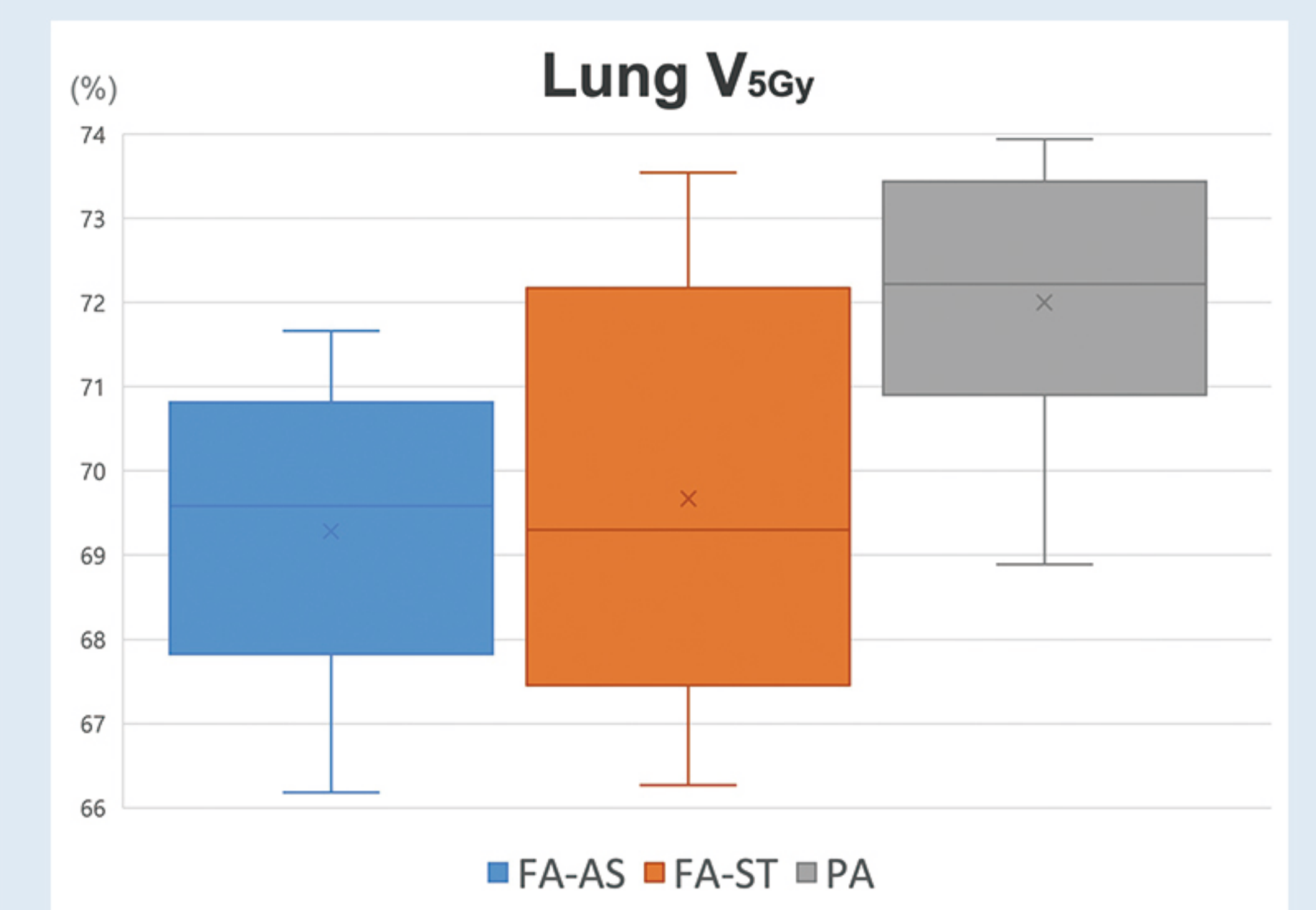


Fig. 2. Comparison of Lung  $V_{5Gy}$ ,  $D_{mean}$ , 50% Isodose Volume, Total MU

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