UAB MEDICINE | HEERSINK School of Medicine

SU-315-GPD-T-422

2026 JOINT AAPM | COMP MEETING
JULY 19–22 | VANCOUVER, BC

Practice Makes Faster in CTgART: Objective Evidence That Experience Improves Adaptor Efficiency

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PURPOSE

CT-guided adaptive radiotherapy (CTgART) introduces substantial workflow complexity and resource demands. While clinical experience is expected to improve efficiency, the magnitude and structure of adaptive learning have not been well quantified using objective data. This study quantifies programmatic and individual learning effects, evaluates complexity-dependent efficiency gains, and characterizes steady-state performance in a comprehensive CTgART program.

METHODS

- Workflow data from Varian Ethos logs, Aug 2021 – Dec 2025: **4,252 fractions**, **286 patients**.
- Complexity via intent-specific median D2D with patient-level deviation adjustment (Simple / Moderate / Complex).
- Learning was evaluated using a stratified experience vs performance trend analysis and a time to steady-state analysis.
- **Steady state** = earliest fraction where rolling median D2D stays within ±5% of the late-phase median for ≥20 consecutive fractions.

KEY RESULTS

4,252
Fractions / 286 pts

33.8min
5 Yr Median D2D

29.5 min
MD2D -Simple

34.5 min
MD2D -Moderate

48.3 min
MD2D -Complex

0.20 min per ln(Session)
median improvement rate

27.2 %
Largest workflow step improvement

11.9%
Median Adaptor improvement in D2D from initial to Steady State

~30
Fractions to steady state

KEY TABLES

Quantitative overview of the population characteristics and key programmatic metrics.

Metric		Value
Population Characteristics		
Unique Patients		286
Unique Intents		298
Adaptive Sessions		4,280
Unique Anatomical Treatment Sites (Intents)		28
SBRT %		16.2 %
Average number of sessions per patient		15
Adaptive Plan Selection Rate (%)		97.3 %
Number of Sessions Per Anatomical Region		
Pelvis		2566 (59 %)
Thorax		583 (14 %)
Breast		497 (12 %)
Abdomen		286 (6 %)
Head and Neck		110 (3 %)
Extremities		26 (1 %)
Other		212 (5 %)
Software Versions		
Ethos Version 1	Adaptive Sessions	2797
	Cumulative Median Door-to-Door	33.9 min
Ethos Version 2	Adaptive Sessions	1483
	Cumulative Median Door-to-Door	32.1 min
Overall Programmatic Workflow (Avg ± STD)		
Anatomy Review		5.3 ± 4.6 min
Target Review		5.2 ± 11.9 min
Plan Review and Selection		6.6 ± 4.0 min
Delivery Time		8.3 ± 3.6 min
Total Contouring Time		17.2 ± 8.9 min
Total Adaptive Time		26.1 ± 10.3 min
Adaptive Door-to-Door		32.8 ± 11.6 min
Complexity-Stratified Median Workflow Duration		
Median D2D - Simple		29.5 min
Median D2D - Moderate		34.6 min
Median D2D - Complex		52.2 min

Steady-State Workflow Duration by Complexity

Complexity	Median D2D	75th Percentile	90th Percentile
Simple	29.50 min	34.46 min	41.63 min
Moderate	34.55 min	39.86 min	47.48 min
Complex	52.22 min	60.94 min	72.70 min
Overall	33.76 min	40.05 min	54.07 min

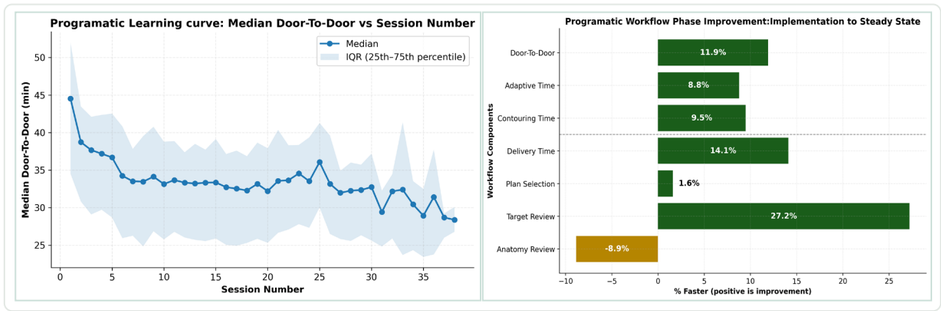

Figure 1.
(A) Median door-to-door treatment time is shown as a function of session number across all adaptive fractions. The solid line with markers represents the median treatment time at each session, while the shaded region denotes the interquartile range (IQR; 25th–75th percentile).
(B) Programmatic Workflow Phase Improvement: Implementation to Steady State

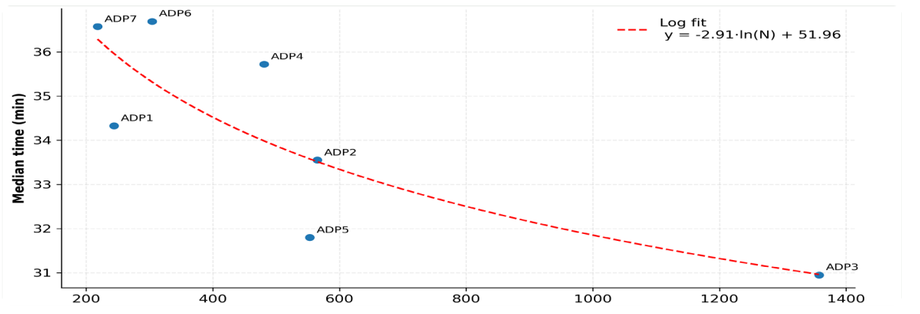

Figure 2. Adaptor Experience vs Median Door-To-Door Treatment Time for All Performed Cases - logarithmic learning (0.20 min per ln(session)).

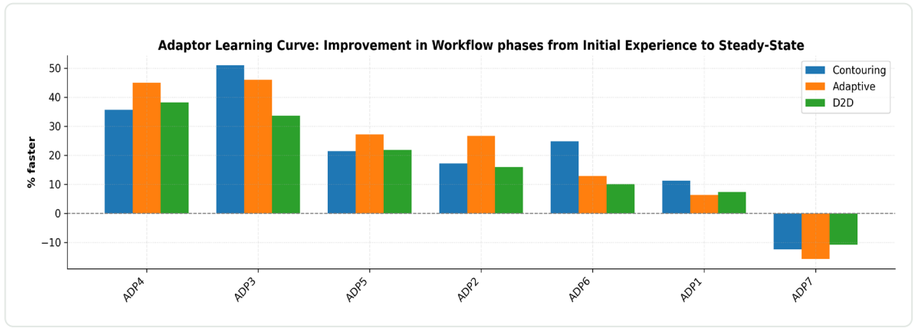

Figure 3. Adaptor Learning Curve: Improvement in Workflow Phases from Initial Experience to Steady-State

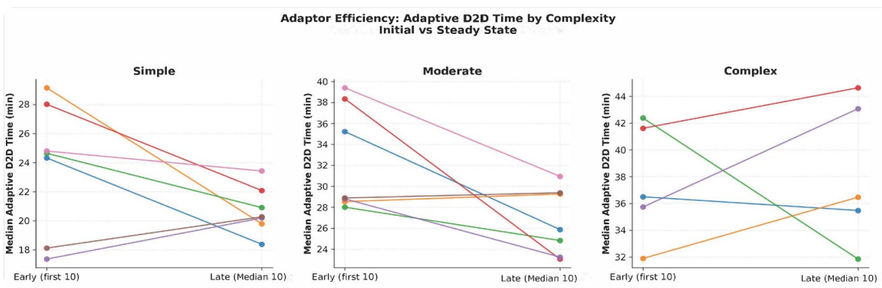

Figure 4. Early vs late D2D by complexity — Moderate improves most; Complex stays challenging.

CONCLUSIONS

CTgART efficiency improves with experience for both the program and individuals, and learning is strongly dependent on **treatment complexity and repetition** — largest for Moderate cases and minimal for Simple. These objective, log-derived benchmarks (≈30 fractions to steady state) can inform training expectations, staffing models, and operational planning.

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Funding. Supported in part by NIH/NCI award L30 CA284339 to Dennis N. Stanley, PhD.