When Is Staging Complex Adult Spinal Deformity Advantageous?: Predictive Analysis Identifying Subsets of Patient Who Benefit From Staged Combination-Approach Surgery

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INTRODUCTION: Due to technical intricacy and increased physiologic stress endured by patients during combined-approach complex adult spinal deformity surgery, surgeons may choose to stage such procedures. Yet, there remains a paucity in literature assessing which variables are predictive of optimal outcome in staged versus same-day procedures.

METHODS:

Patients with minimum baseline (BL) and peri-operative/six week (6W) data were stratified based on whether their surgeon chose to perform single-stage (Same-Day) or multistage (Staged) combined-approach ASD surgery, excluding planned multi-hospitalization. Means comparison analysis assessed baseline demographic, radiographic, and surgical differences between cohorts. Backstep logistic regression and conditional inference tree (CIT) analysis identified variable thresholds correlating to Optimal Outcome in each cohort, defined as lack of any index surgery-related intraoperative or in-hospital adverse event.

RESULTS: 439 patients (64.0±9.3yrs, 68% F, 28.7±5.5kg/m^2) were isolated. 58.7% of patients were Same-Day, while 41.3% were Staged. Cohorts were demographically comparable (all $p>.05$), though Staged patients were significantly more frail per total Edmonton Frailty score ($p=.043$). Cohorts were also comparable in magnitude of planned correction of C7-S1 SVA, PI-LL, and T4-T12 kyphosis (all $p>.05$). At BL, Staged patients also reported greater NRS-Back pain versus Same-Day patients ($p=.002$). Surgically, Same-Day patients were more likely to be undergoing revision for motor deficit ($p=.028$), and Staged patients reported significantly greater hospital length of stay ($p=.013$). Controlling for BL age, frailty, and levels fused, Staged patients reported significantly higher PROMIS-Discretionary Social Activities (DSA) scores by 6W ($p=.029$). Radiographic outcomes by 6W were comparable between cohorts, both in magnitude of change from baseline and in gross parameters (all $p>.05$). However, Same-Day patients were significantly more likely to have more in-hospital complications, controlling for age, BL frailty, and levels fused ($p=.013$). Predictive analysis via backstep regression revealed only CCI ≤ 1.0 to be predictive of Optimal Outcome in Same-Day patients, while Edmonton Frailty total ≥ 7 ($p=.036$), ≥ 9 levels fused ($p=.016$), and baseline PI-LL ≥ 15.3° ($p=.028$) predicted Optimal Outcome for Staged patients. Yet, staging alone was not significantly predictive of achieving Optimal Outcome peri-operatively ($p=.056$).

DISCUSSION AND CONCLUSION: The present study demonstrates that while staged and same-day combined-approach surgery offer comparable radiographic and patient-reported outcomes peri-operatively, certain subsets of complex adult spinal deformity patients may benefit from staged surgery at the expense of increased hospital length of stay. Predictive analysis reveals that patients with increased frailty, moderate-severe PI-LL mismatch, and increased planned levels fused may be at lessened risk of peri-operative surgery-related complications if undergoing staged surgery, though staging itself is not a significant predictor of reducing adverse events.

Fig 1. Surgical Differences: Staged vs Same-Day

Surgical Differences in Same-Day vs Staged Patients				
Total Op Time (min)	Same Day	597.49	139.18	p=.333
	Staged	639.92	206.53	
Levels Fused	Same Day	11.86	3.97	p=.128
	Staged	13.35	3.39	
EBL Total (mL)	Same Day	1250.68	778.94	p=.241
	Staged	1562.31	1308.62	
VCR or Corpectomy (y/n)	Same Day	3.00%	16.40%	p=.803
	Staged	4.00%	19.60%	
Length of Stay (Days)	Same Day	7.56	3.32	**p=.013***
	Staged	9.00	1.22	
SICU Stay (y/n)	Same Day	59.00%	49.80%	p=.640
	Staged	65.00%	48.50%	