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Clinical Performance of da Vinci 5 Versus Xi for Robotic Anatomic Lung Resection: A Propensity-Weighted Analysis

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Abstract

Objective

The da Vinci 5 (DV5) system has purported advantages over existing platforms, including forced feedback. We compare perioperative safety, operative efficiency and early oncologic quality between DV5 and Xi robotic platforms for anatomic lung resection.

Methods

A total of 419 robotic lung resections were performed between January 2025 and August 2026. Propensity-score overlap weighting balanced and matched 294 patients (47 DV5, 247 Xi) for age, sex, ASA class, BMI, forced expiratory volume in 1 second, tumor size, clinical T and N category, resection type and laterality. Effects were reported with robust and bootstrap 95% confidence intervals. Sensitivity analyses included 1:1 and 1:3 propensity matching comparisons and E-value assessment.

Results

From January 2025 to August 2026, 294 patients (47 DV5, 247 Xi) had balanced baseline characteristics (SMD < 0.01). Operative time was shorter with DV5 (96.4 vs 118.7 minutes; 95% CI, − 36.2 to − 8.5). Lymph node yield was comparable (DV5 29.9 vs Xi 31.6; [− 7.2 to + 3.7]). Blood loss ($p < 0.01$), length of stay (1.05 vs 1.28 days; [− 0.53, + 0.06]) and stapler loads (8.5 vs 9.6; [− 2.81 to + 0.55]) were numerically lower with DV5. Major complications were numerically lower with DV5 (1/47 [2.0%] vs 20/247 [8.2%]; −16.0 to + 3.6). Both had 100% R0 resections and no conversion. There was no 30- or 90-day mortality.

Conclusions

Anatomic lung resection for early-stage lung cancer with the robotic DV5 platform preserves the safety and oncologic quality of the Xi system while being associated with shorter operative times. Prospective, multi-institutional studies are required to evaluate these findings.

Introduction

Surgical resection remains the cornerstone of curative-intent treatment for early-stage non-small cell lung cancer (NSCLC), with anatomic resection and systematic lymph node evaluation representing the standard oncologic operation for most patients.[1] Minimally invasive surgery (MIS) has increasingly replaced thoracotomy, with video-assisted thoracoscopic surgery (VATS) and robotic-assisted thoracic surgery now widely used for anatomic lung resection. Compared with thoracotomy, MIS is associated with less perioperative morbidity, shorter length of stay, and faster recovery without compromising oncologic principles.[1, 2]

Robotic-assisted thoracic surgery has become an established approach to anatomic lung resection. Three-dimensional visualization, wristed instrumentation, and enhanced dexterity may facilitate hilar dissection and lymph node evaluation, particularly in technically complex cases.[3] Large propensity-adjusted and multicenter studies have demonstrated perioperative outcomes comparable to VATS, with lower conversion rates and, in several series, more extensive lymph node evaluation.[4, 5]

Robotic technology continues to evolve, with newer platforms and single-port systems expanding the range of minimally invasive approaches available for anatomic lung resection.[6, 7] The da Vinci 5 (DV5) represents the fifth-generation multiport platform and incorporates substantial hardware and software changes compared with the established da Vinci Xi (Xi), including force-feedback instrumentation. [8, 9] The DV5 received US Food and Drug Administration clearance in 2024, including for thoracic procedures. Force Feedback allows the surgeon to perceive forces applied at the instrument tip, a capability not available on Xi. Although early experience in other surgical specialties has suggested potential improvements in operative efficiency, whether these technological changes translate into measurable differences during anatomic lung resection remains unknown.[8] To our knowledge, no published clinical study has directly compared DV5 with Xi for thoracic anatomic lung resection.

We compare DV5 with Xi for robotic lobectomy and segmentectomy for early-stage lung cancer using propensity overlap weighting. We evaluate three clinically relevant domains, including perioperative safety, operative efficiency and early measures of oncologic quality. The objective is to determine whether introduction of the newest-generation robotic platform preserved the outcomes achieved with the established Xi platform while identifying potential differences in surgical performance.

Materials and methods

Study Design

This is a single-center retrospective cohort study comparing robotic anatomic lung resection performed with the da Vinci 5 (DV5) and da Vinci Xi (Xi) multiport. All consecutive patients undergoing robotic lobectomy and segmentectomy on the DV5 and Xi platform during the study period were reviewed. Institutional review board approval was obtained (IRB# i26-01265), with waiver of informed consent because of the retrospective study design.

Patient Selection

Consecutive patients undergoing robotic lobectomy or segmentectomy for early-stage lung cancer were eligible. Wedge resections and other nonanatomic resections were excluded. There was one DV5 patient with advanced disease (cT4N2; tumor size, 8.2 cm), that was excluded. The derivation of the final analytic cohort is shown in Fig. 1.

Data Collection

Demographic, clinical, operative, and pathologic data were obtained from the electronic medical record. Baseline variables included age, sex, body mass index, American Society of Anesthesiologists (ASA) class, forced expiratory volume in 1 second as percentage predicted (FEV1%pre), tumor size, clinical T and N category, type of resection (lobectomy or segmentectomy), and laterality. Perioperative and pathologic outcomes were collected for all patients.

Surgical Approach

All operations were multiport robotic anatomic lung resections performed by thoracic surgeons at our institution using either the DV5 or Xi platform. Standard oncologic principles were followed for hilar dissection, anatomic pulmonary resection, and systematic lymph node evaluation as previously described. [10] All patients underwent standard robotic positioning and port placement. A complete mediastinal lymph node dissection was performed in all cases, including levels 7, 8, 9, 10, 11, 12, as well as levels 2 and 4 (right) or 5 and 6 (left). A robotic stapler was used to divide structures.

Outcomes

Outcomes were evaluated across three domains: perioperative safety, operative efficiency and oncologic quality. Safety outcomes included major postoperative complications, defined as Clavien-Dindo grade III or greater; conversion to thoracotomy; 30-day readmission; and 30- and 90-day mortality. Operative outcomes included operative time, estimated blood loss as a categorized variable (0–20, 20–40, 40–60, > 60 mL), chest tube duration and hospital length of stay. Measures of oncologic quality included R0 resection, number of lymph nodes harvested, number of nodal stations evaluated, and nodal upstaging. Total stapler loads were also recorded as a measure of operative resource utilization.

Statistical analysis

Baseline characteristics are presented as mean (standard deviation) for continuous variables and n (%) for categorical variables. Because the two groups differed at baseline, propensity-score overlap weighting was used to balance measured confounders. The propensity model was a logistic regression including age, sex, BMI, ASA class, FEV_1 (% predicted), tumor size, clinical T category, clinical N category, resection type and laterality. Covariate balance was assessed by the absolute standardized mean difference (SMD), with balance pre-specified as $|SMD| < 0.10$ for all covariates. The effective sample size was calculated as $(\Sigma w)^2 / \Sigma w^2$.

Results are reported as absolute effects, risk differences for binary outcomes and differences in means for continuous outcomes, with 95% confidence intervals derived from robust (sandwich) variance estimation and confirmed by bootstrap resampling.

Sensitivity analyses

We tested the robustness of the primary findings in two ways. First, we repeated the analysis using propensity-score matching (1:1 and 1:3 nearest-neighbor matching on the logit of the propensity score, caliper 0.2 SD, without replacement). This checked whether the direction of the effects held under a different estimate (the average treatment effect in the treated).

Second, we calculated E-values for the primary complication endpoint to assess robustness to unmeasured confounding. Because the 95% CI crossed the null, the E-value for the confidence limit was 1 and was not reported separately.

Third, because operative time may be influenced by individual surgeon speed, we performed a sensitivity analysis restricted to the two surgeons who used both platforms and accounted for the majority of the cohort (55%). Within-surgeon differences in operative time (DV5 − Xi) were estimated with an unadjusted Welch t contrast and multivariable linear regression with surgeon fixed effects and propensity-model covariates. All analyses were performed in Python 3.9.6, with two-sided $P < 0.05$ considered statistically significant.

Results

Study Cohort and Baseline Characteristics

The final cohort included 294 patients undergoing robotic anatomic lung resection for early-stage lung cancer with 47 patients in the DV5 group and 247 resected with the Xi platform. Before weighting, the largest differences between groups were in clinical T category (cT2: 21.3% DV5 vs 10.9% Xi) and tumor size (mean, 1.9 vs 1.7 cm). Smaller differences were observed in body mass index (26.0 vs 26.8 kg/m²), FEV_1 (97.8% vs 95.1% predicted), resection type (segmentectomy, 44.7% vs 50.6%) and laterality (right-sided resection, 59.6% vs 54.3%). Age (69.7 vs 69.3 years), sex (male, 29.8% vs 34.4%), ASA class (2.7 vs 2.8), and clinical nodal status (cN0, 97.9% vs 97.6%) were similar. Baseline characteristics before and after weighting are presented in Table 1.

Table 1
Baseline Characteristics and Demographics

Characteristic	DV5 unweighted	Xi unweighted	DV5 weighted	Xi weighted	SMD unw. → wtd.
N	47	247	47	247	-
Panel A - propensity-score / overlap-weighting model covariates					
Age, yr	69.7 (10.3)	69.3 (10.5)	69.4 (10.2)	69.5 (10.6)	0.042 → 0.000
Sex, male - n (%)	14 (29.8%)	85 (34.4%)	31.1%	31.1%	0.099 → 0.000
Body-mass index, kg/m²	26.0 (4.8)	26.8 (5.5)	26.1 (4.9)	26.1 (5.3)	0.162 → 0.000
ASA class, ordinal 1–4	2.7 (0.4)	2.8 (0.5)	2.8 (0.4)	2.8 (0.5)	0.072 → 0.000
FEV1, % predicted	97.8 (24.8)	95.1 (18.3)	96.8 (24.7)	96.8 (18.1)	0.122 → 0.000
Tumor size, cm	1.9 (1.0)	1.7 (1.0)	1.9 (1.0)	1.9 (1.1)	0.268 → 0.000
Clinical T stage, T2 - n (%)	10 (21.3%)	27 (10.9%)	17.9%	17.9%	0.284 → 0.001
Clinical N stage, N1 - n (%)	1 (2.1%)	6 (2.4%)	2.4%	2.4%	0.020 → 0.002
Resection = segmentectomy - n (%)	21 (44.7%)	125 (50.6%)	47.0%	47.0%	0.119 → 0.000
Laterality = right - n (%)	28 (59.6%)	134 (54.3%)	57.4%	57.4%	0.108 → 0.000

Values are mean (SD) for continuous variables, median [IQR] for pack-years, and n (%) for categorical variables; weighted columns use the frozen overlap weight ow (ATO: w = 1 − PS for DV5, w = PS for Xi). SMD = absolute standardized mean difference, unweighted → overlap-weighted; common balance threshold < 0.10.

Characteristic	DV5 unweighted	Xi unweighted	DV5 weighted	Xi weighted	SMD unw. → wtd.
Panel B - additional baseline characteristics					
Smoking status					
Never	21 (44.7%)	92 (37.2%)	43.8%	40.0%	-
Former	24 (51.1%)	135 (54.7%)	52.3%	50.9%	-
Current	2 (4.3%)	20 (8.1%)	4.0%	9.0%	-
Pack-years, median [IQR]	12.0 [0.0–33.5]	15.0 [0.0–30.2]	14.0	15.0	-
ASA class, categorical					
II	12 (25.5%)	60 (24.3%)	24.9%	26.6%	-
III	35 (74.5%)	182 (73.7%)	75.1%	71.7%	-
IV	0 (0.0%)	5 (2.0%)	0.0%	1.7%	-
Tumor location (lobe)					
Right upper lobe	13 (27.7%)	73 (29.6%)	26.6%	30.7%	-
Right lower lobe	13 (27.7%)	37 (15.0%)	26.0%	16.9%	-
Right middle lobe	2 (4.3%)	23 (9.3%)	4.7%	9.4%	-
Left upper lobe	9 (19.1%)	70 (28.3%)	20.0%	26.5%	-
Left lower lobe	9 (19.1%)	42 (17.0%)	20.2%	15.8%	-
Multi-lobe / other	1 (2.1%)	2 (0.8%)	2.4%	0.7%	-

Values are mean (SD) for continuous variables, median [IQR] for pack-years, and n (%) for categorical variables; weighted columns use the frozen overlap weight ow (ATO: w = 1 − PS for DV5, w = PS for Xi). SMD = absolute standardized mean difference, unweighted → overlap-weighted; common balance threshold < 0.10.

Covariate Balance After Overlap Weighting

Propensity-score overlap weighting achieved excellent balance across all measured covariates, with all weighted SMDs < 0.01. Covariate balance and the improvement in propensity-score overlap before and after weighting are shown in Fig. 2.

Perioperative Safety

There was no 30- or 90-day mortality and no conversion to thoracotomy in either group. Major complications (Clavien-Dindo grade ≥ III) occurred in 2.0% of DV5 and 8.2% of Xi patients, corresponding to a weighted risk difference of − 6.2% (robust 95% CI, − 16.0% to 3.6%). The bootstrap 95% CI was − 11.3% to − 0.4% (Fig. 3). Freedom from chest-tube drainage over time from operating-room exit, restricted to the single surgeon (RC) is shown in Fig. 4. Thirty-day readmission was similar between DV5 and Xi (4.4% vs 4.5%; risk difference, − 0.1%; 95% CI, − 9.3% to 9.2%).

Operative Outcomes

Operative time was shorter with DV5 than Xi (mean, 96.4 vs 118.7 minutes; adjusted difference, − 22.3 minutes; robust 95% CI, − 36.2 to − 8.5; bootstrap 95% CI, − 30.8 to − 13.5) (Fig. 5). Estimated blood loss was lower with DV5, with 97.9% of patients having ≤ 20 mL compared with 82.7% of Xi patients and no DV5 patient had > 40 mL versus 11.0% of Xi patients

Mean hospital length of stay was 1.05 days with DV5 and 1.28 days with Xi (difference, − 0.23 days; robust 95% CI, − 0.53 to 0.06; bootstrap 95% CI, − 0.40 to − 0.07). Chest tube duration was similar between groups (23.9 vs 27.8 hours; difference, − 3.9 hours; 95% CI, − 33.4 to 25.6). However, 22 of 47 patients (46.8%) resected with the DV5 left the operating room without a chest tube, compared with 13.8% in the Xi group. Because this practice was confined to a single surgeon, the comparison is best made within that surgeon's own cases: 66.7% of DV5 (22/33) versus 44.2% of Xi (34/77) patients left the operating room tube-free.

Oncologic Quality

R0 resection was achieved in 100% of patients in both groups Pathologic characteristics by platform are summarized in Supplementary Table S1. Lymph node yield was similar between DV5 and Xi (mean, 29.9 vs 31.6 nodes; difference, − 1.8; 95% CI, − 7.2 to 3.7). Nodal upstaging occurred in 0% of DV5 and 6.5% of Xi patients, corresponding to a weighted risk difference of − 6.5% (robust 95% CI, − 15.4% to 2.4%; bootstrap 95% CI, − 10.5% to − 3.0%). All outcomes are presented in Table 2 and summarized graphically in Fig. 3.

Table 2
Overlap-weighted perioperative, safety and oncologic outcomes

Endpoint	DV5 (n)	Xi (n)	Effect (DV5 − Xi)	95% CI robust	95% CI bootstrap	p†
Major complication, Clavien–Dindo ≥ III	2.0% (47)	8.2% (247)	−6.2 pp	−16.0, + 3.6	−11.3, − 0.4	0.214
Perioperative / technical						
Operative time, skin-to-skin, min	96.4 (47)	118.7 (247)	−22.3	−36.2, − 8.5	−30.8, − 13.5	0.002
Estimated blood loss, mL	15.6 (46)	21.0 (221)	−5.4	−10.2, − 0.6	−8.2, − 2.5	0.028
EBL, categorized						
0–20 mL	97.9% (47)	82.7% (221)	—	—	—	—
20–40 mL	2.1% (47)	6.3% (221)	—	—	—	—
40–60 mL	0.0% (47)	10.6% (221)	—	—	—	—
>60 mL	0.0% (47)	0.4% (221)	—	—	—	—
Chest tube duration, h	23.9 (47)	27.8 (246)	−3.9	−33.4, + 25.6	−21.8, + 21.9	0.795
Length of stay, d	1.05 (47)	1.28 (247)	−0.23	−0.53, + 0.06	−0.40, − 0.07	0.124
Stapler loads used, n	8.5 (47)	9.6 (245)	−1.13	−2.81, + 0.55	−2.13, − 0.22	0.189
Safety						
30-day mortality	0.0% (47)	0.0% (247)	-			
90-day mortality	0.0% (47)	0.0% (247)	-			
30-day readmission	4.4% (47)	4.5% (247)	−0.1 pp	−9.3, + 9.2	−6.2, + 7.3	0.988
Conversion to open	0.0% (45)	0.0% (247)	-			

† P values from weighted generalized linear models within the overlap-weighted pseudo-population; robust (sandwich) variance estimator. Two-sided P < 0.05 considered significant.

Endpoint	DV5 (n)	Xi (n)	Effect (DV5 − Xi)	95% CI robust	95% CI bootstrap	p†
Lymph nodes harvested, n	29.9 (47)	31.6 (246)	−1.78	−7.25, + 3.68	−4.89, + 1.31	0.522
LN stations sampled, n	8.04 (47)	7.57 (246)	+ 0.47	+ 0.03, + 0.90	+ 0.16, + 0.77	0.035
Nodal upstaging, cN0→pN1/pN2	0.0% (34)	6.5% (241)	−6.5 pp	−15.4, + 2.4	−10.5, − 3.0	0.152
Margin R0	100% (41)	100% (247)	-			

† P values from weighted generalized linear models within the overlap-weighted pseudo-population; robust (sandwich) variance estimator. Two-sided P < 0.05 considered significant.

Sensitivity Analyses

The direction and magnitude of the primary findings were similar in the propensity-matched sensitivity analyses (Supplementary Table S2). Operative time remained shorter with DV5 after both 1:1 matching (difference, − 25.2 minutes; 95% CI, − 37.5 to − 12.9) and 1:3 matching (difference, − 21.5 minutes; 95% CI, − 31.5 to − 11.4), compared with − 22.3 minutes in the overlap-weighted analysis. Lower estimated blood loss was also preserved in the 1:1 (− 8.1 mL) and 1:3 (− 5.5 mL) matched analyses. The corresponding differences in nodal upstaging were − 7.0% and − 5.1%, respectively. In the 1:3 matched cohort, DV5 was also associated with shorter length of stay (difference, − 0.21 days; 95% CI, − 0.38 to − 0.03).

Two surgeons performed cases on both platforms and together accounted for 161 of 294 patients (54.8%). Within each surgeon's own practice, operative time was directionally shorter with DV5 (Surgeon 1: −9.2 minutes, 95% CI − 18.8 to + 0.4; Surgeon 2: −1.8 minutes, 95% CI − 32.1 to + 28.5, Supplementary Figure S1).

Discussion

In this propensity-weighted comparison of DV5 and Xi for robotic anatomic lung resection for early-stage lung cancer, the principal finding was a 22-minute reduction in operative time with the DV5 robotic platform. This difference was consistent across overlap weighting and both propensity-matched sensitivity analyses. There was no 30- or 90-day mortality, no conversion to thoracotomy and R0 resection was achieved in all patients on both platforms. Lymph node yield and chest tube duration were also similar. Major complications and length of stay were numerically lower with DV5, although the primary robust confidence intervals included the null. These findings suggest that early adoption of DV5 preserved the perioperative safety and oncologic quality achieved with Xi while improving operative

efficiency. However, some of these differences are possibly explained by the surgeon practices (only RJC removed the CT in the OR) and did the majority of these operations.

Evolution of Robotic Platforms

The da Vinci platform has evolved through several generations designed to improve visualization, instrumentation and operative workflow.[11] In the present study, the consistent reduction in operative time across three adjusted analyses suggests that DV5 may provide a measurable efficiency advantage during anatomic lung resection.

To our knowledge, this is the first clinical comparative analysis of the DV5 and Xi platforms in thoracic surgery, as no prior study has compared perioperative or oncologic outcomes between these two systems for anatomic lung resection. Published clinical comparisons of DV5 and Xi remain limited in other surgical specialties as well. In a single-center study of 204 patients undergoing robotic-assisted radical prostatectomy, DV5 was associated with shorter console time and a modest reduction in total operative time, without differences in complications, length of stay, or margin status.[8] Our findings are directionally similar. This difference should not be interpreted as evidence that DV5 inherently reduces operative time by 22 minutes across procedures. Anatomic lung resection differs substantially from prostatectomy in operative steps, tissue planes and instrumentation. Nevertheless, both studies identify operative efficiency, as the principal measurable difference between the two platforms.

Potential Mechanisms

Force feedback is the most distinctive technical addition to DV5. The system measures forces at the instrument tip and transmits push-pull forces to the surgeon through the console controls.[12] Importantly, thoracic-specific clinical data now demonstrate that this technology changes tissue handling. In a multicenter analysis of DV5 thoracic procedures, increasing force-feedback sensitivity was associated with progressively lower average instrument-tip forces and less time spent above high-force thresholds.[13] Similar findings have been reported in colorectal and rectal surgery. [9, 14] These data may provide a plausible mechanism by which force feedback may allow for more controlled retraction and dissection.

DV5, however, differs from Xi in more than force feedback. The platform incorporates higher-resolution visualization, with approximately four times the number of pixels, as well as changes in console design and system control. [15] Improved visualization may facilitate earlier identification of tissue planes and small vascular or lymphatic structures and reduce unnecessary dissection.[16] In robotic surgery, improved visualization across earlier da Vinci generations has also been associated with less surgeon-reported eye fatigue.[17]

Ergonomics may also contribute. DV5 provides a greater range of viewer motion and console adjustment, allowing the surgeon to maintain a more neutral head and neck position. Prior surveys demonstrate that ergonomic limitations remain common even during robotic surgery: 56% of robotic

surgeons in one study reported procedure-related physical symptoms, most commonly involving the neck and fingers and surgeons who reported greater confidence in their ergonomic settings experienced fewer symptoms.[17] Current surgical ergonomics recommendations emphasize maintaining a neutral neck position, optimizing viewer height and tilt, supporting the upper extremities, and minimizing repeated repositioning during robotic surgery.[18]

When one compares the sole surgeon in this series who was willing to remove the CT in the operating room, the data shows a greater likelihood of being able to remove the tube if the operation was performed on a DV5 system: 22 out of 35 patients or 63% on the DV5 system compared to 34 out of 77 patients, or 44% on the Xi.

However, our study cannot determine whether force feedback caused the observed reduction in operative time or air leak at the end of the operation. Force telemetry was not collected and the difference in estimated blood loss, is not clinically meaningful. DV5 also incorporates changes in system architecture, computing, instrumentation and operating-room workflow that may influence efficiency independently of force feedback. Furthermore, operative time is particularly susceptible to temporal confounding. Increasing surgeon experience, refinement of technique, differences in case selection, and operating-room team performance may all contribute to the observed effect and cannot be fully addressed by propensity weighting based on patient characteristics. The consistency of the operative-time difference across sensitivity analyses strengthens the association but does not establish a causal effect of the platform.

Chest Tube Management

An exploratory observation was that a minority of patients left the operating room without a chest tube. This practice was confined entirely to a single surgeon. Because DV5 cases were disproportionately performed by this surgeon (70.2% of DV5 vs 31.3% of Xi cases), a pooled comparison would confound platform with operator. We therefore restricted this analysis to that surgeon's own practice, holding drain philosophy constant. Within this surgeon, 66.7% of DV5 versus 44.2% of Xi patients left the operating room tube-free (unadjusted risk difference, + 22.5 percentage points; 95% CI, + 3.0 to + 42.0; Fig. 4); after covariate adjustment the association was attenuated (odds ratio ≈ 2.4–2.6; P ≈ 0.05).

Selected patients can safely undergo anatomic lung resection without postoperative pleural drainage when adequate aerostasis and hemostasis are confirmed intraoperatively. This strategy has been associated with less postoperative pain and shorter hospitalization, and earlier chest tube removal and mobilization have been associated with discharge on postoperative day 1 after robotic lobectomy.[19, 20]

This finding should be interpreted cautiously. Overall chest tube duration did not differ after weighting, and although the same intraoperative criteria for drain omission were applied throughout the study, the decision remains surgeon-dependent. Even within a single surgeon, accumulating experience and evolving perioperative practice cannot be separated from the platform. We therefore cannot attribute the

greater use of a no-drain strategy to DV5 or to force feedback. Prospective evaluation would be required to determine whether force-informed tissue handling influences postoperative air leak or the ability to safely omit pleural drainage.

Weaknesses

This study has several limitations. First, this is a retrospective, single-center study and platform assignment was determined by availability and surgeon preference rather than randomization. Although overlap weighting achieved excellent balance across measured baseline characteristics, residual confounding remains possible. Temporal confounding is particularly important because DV5 was introduced after substantial institutional experience with robotic lung resection and some of the efficiency gains seen with DV5 may reflect that accumulated experience rather than the platform itself.

Second, the DV5 cohort was small, only 47 patients, limiting power for uncommon outcomes such as major morbidity, conversion and mortality. The absence of these events does not prove the platforms are equivalent; it shows that DV5 is safe and feasible. The absence of nodal upstaging in the DV5 cohort cannot be interpreted as superior oncologic performance.

Third, force-feedback utilization and instrument-level force telemetry were not captured, preventing determination of whether force feedback contributed to the observed differences. Operative time also represents the aggregate result of multiple components of the operation; more granular measurements of docking, console, hilar-dissection, and specimen-extraction times would better identify where any efficiency advantage occurs. Finally, this study evaluates perioperative outcomes and early measures of oncologic quality only. Longer follow-up is required before any conclusions can be made regarding recurrence or survival.

This study has some important strengths. First, to our knowledge, it is the first clinical comparison of the da Vinci 5 and Xi platforms in thoracic surgery and addresses a timely question as centers adopt the newest-generation system without comparative thoracic outcome data. Second, all consecutive eligible resections were included, reducing selection bias no patient had an open approach. Third, both platforms were used contemporaneously at a single high-volume thoracic center, limiting the influence of institutional variation in operative technique, perioperative pathways and postoperative management. Fourth, propensity-score overlap weighting achieved excellent balance across all measured baseline covariates. Fifth, treatment effects were reported with robust and bootstrap confidence intervals, and the principal findings were tested using propensity-matched sensitivity analyses. Finally, the reduction in operative time remained consistent in direction and magnitude across all three analytic approaches.

Conclusion

In robotic anatomic lung resection for early-stage lung cancer, DV5 demonstrated perioperative safety and early oncologic-quality outcomes comparable to Xi while being associated with a consistent reduction in operative time. These early findings support DV5 as a safe and efficient platform for

anatomic lung resection. Larger multi-institutional prospective studies incorporating force-feedback telemetry and more granular operative metrics are needed to determine whether these technological advances translate into reproducible clinical benefits.

Declarations

Competing Interests

Dr. Michael Zervos reports financial relationship with Intuitive Surgical that includes speaking, lecture fees and training courses. Dr. Cerfolio reports equity in Fruit Street, Informed Inc., NovaNav and ENGAUGE (Epiqar); intellectual property related to Tego; and consulting and advisory roles with Informed Inc., NovaNav, Commend Corporation, Intuitive Surgical, and Johnson & Johnson; serves as CEO and President of Rolo-7, C^4, and Coop-Lor-Corporation. Dr. Costas Bizekis reports honoraria from Medtronic, Steris, and Boston Scientific. Dr. Chang reports honoraria from AtriCure and Intuitive Surgical and prior advisory board service for AstraZeneca. All other authors report no conflicts of interest.

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Author Contribution

(I) Conception and design: NP, RJC(II) Administrative support: CB, MZ, RJC(III) Provision of study materials or patients: CB, AJK, SHC, MZ, RJC(IV) Collection and assembly of data: NP(V) Data analysis and interpretation: NP, IK, MZ, RJC(VI) Manuscript writing: NP, CB, AJK, IK, SHC, MZ, RJC(VII) Final approval of manuscript: NP, CB, AJK, IK, SHC, MZ, RJC

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to institutional and IRB restrictions.

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Figures

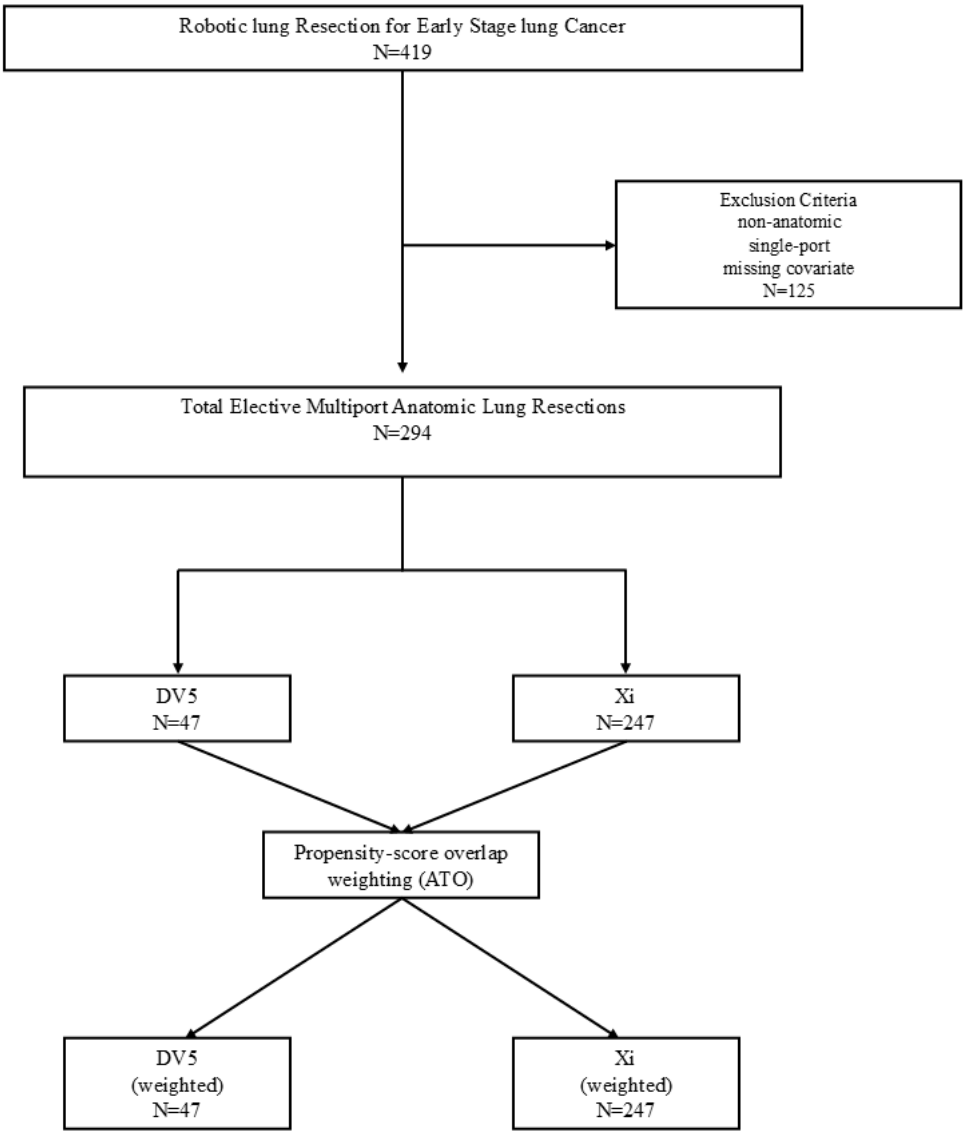


Figure 1

Study flow diagram (CONSORT-style).

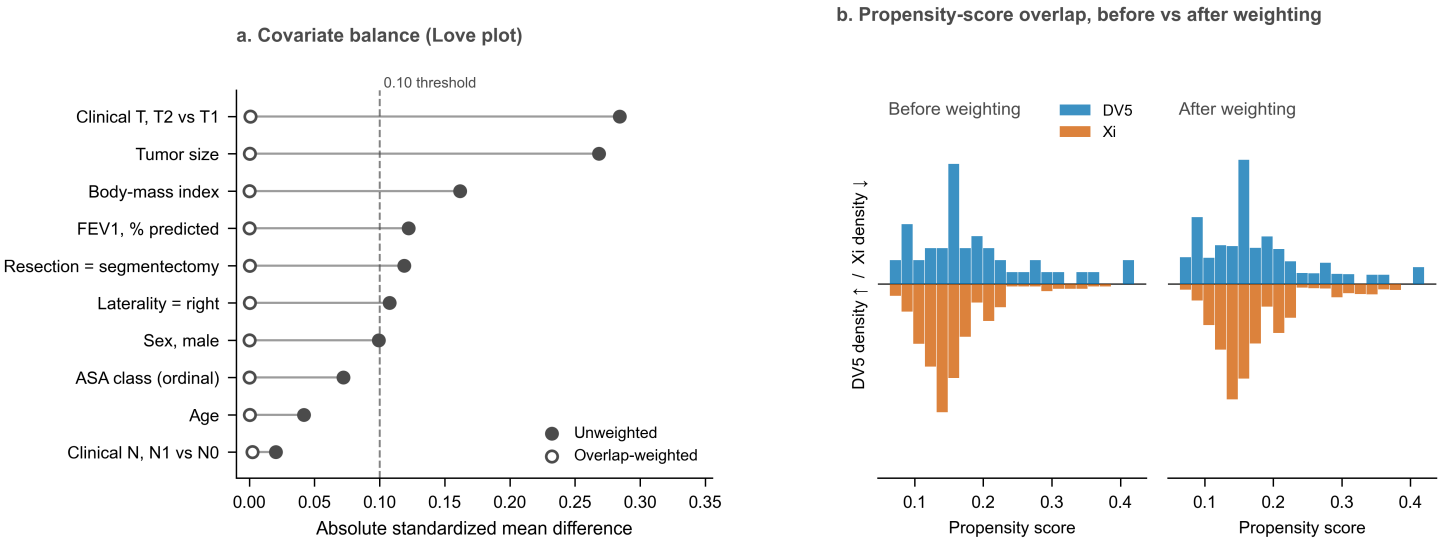


Figure 2

Covariate balance and common support after overlap weighting.

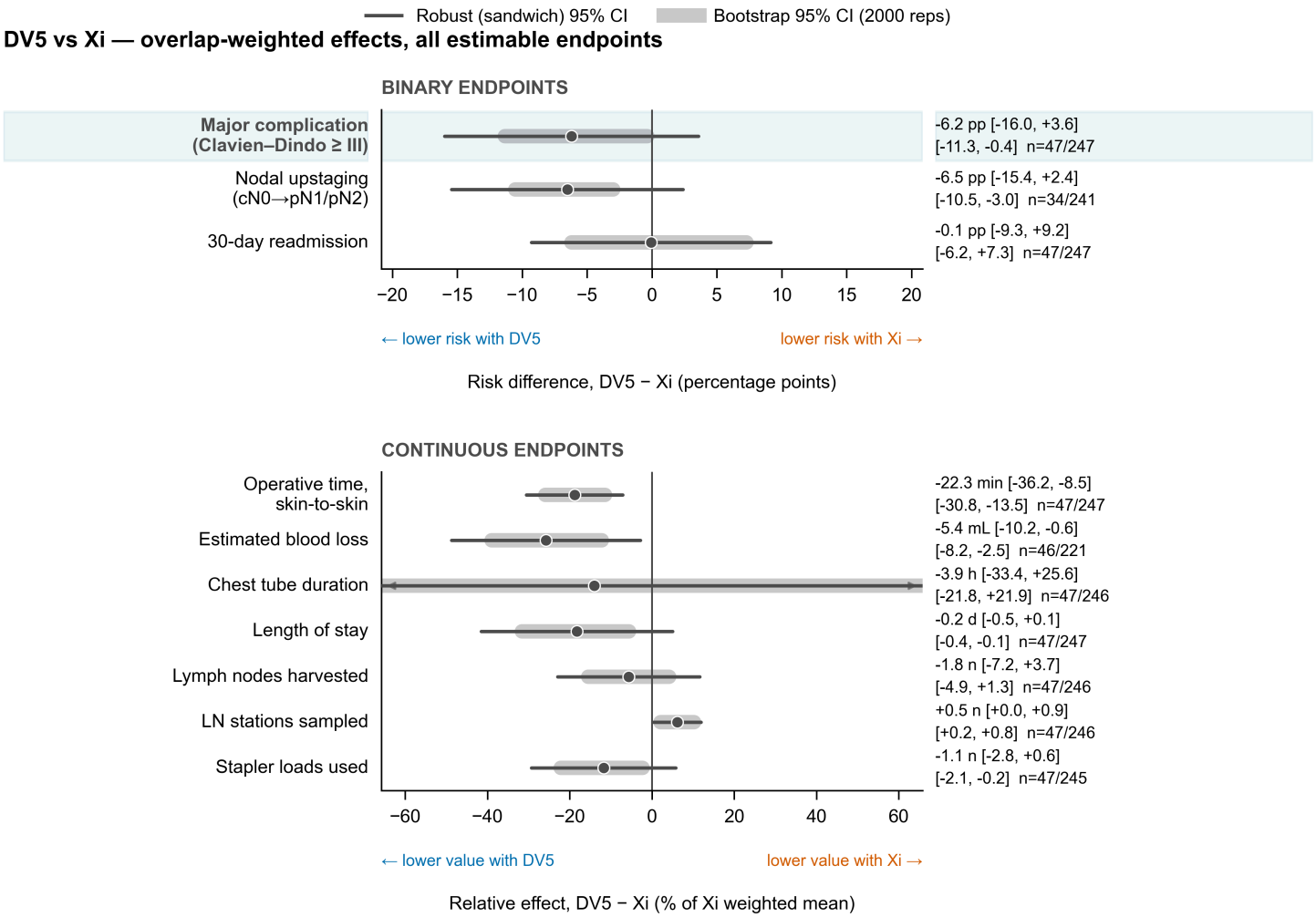


Figure 3

Overlap-weighted treatment effects for DV5 versus Xi across all estimable endpoints.

Chest-tube freedom from drain, surgeon RC only

t=0 (OR-exit) tube-free: 66.7% DV5 vs 44.2% Xi (risk difference +22.5 pp [+3.0, +42.0], unadjusted)

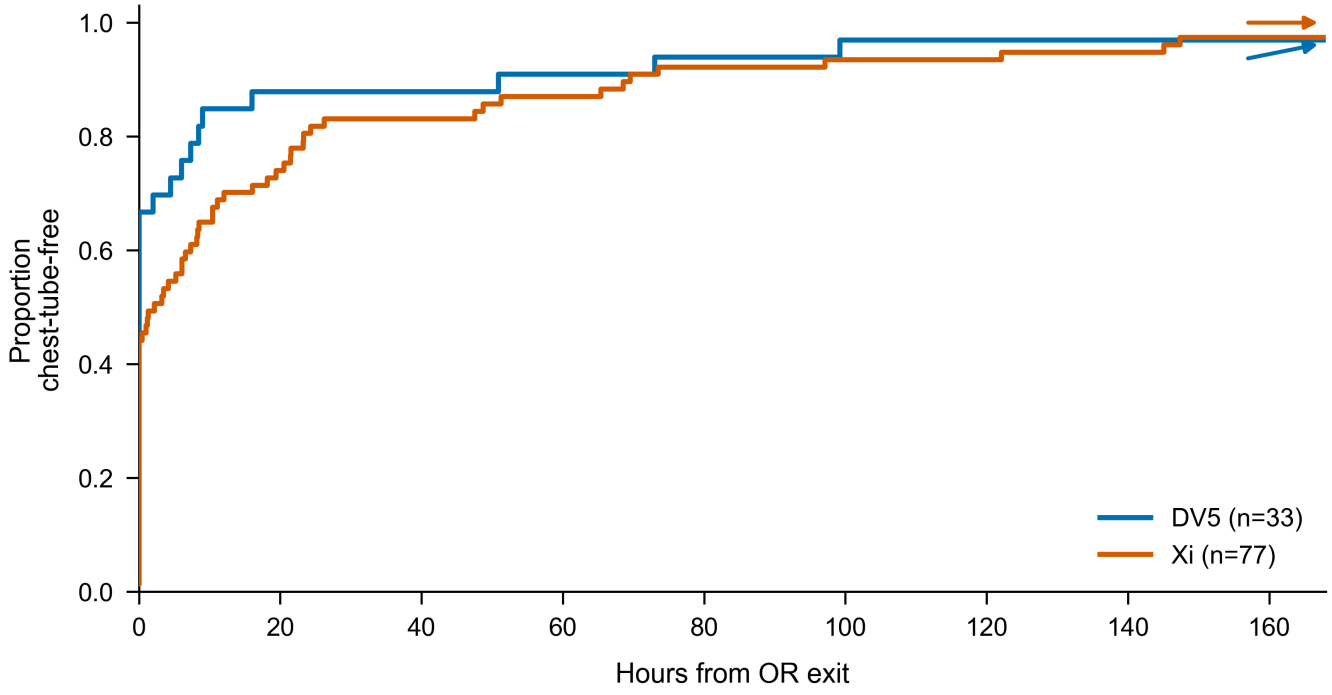


Figure 4

Time to chest-tube freedom, restricted to surgeon RC.

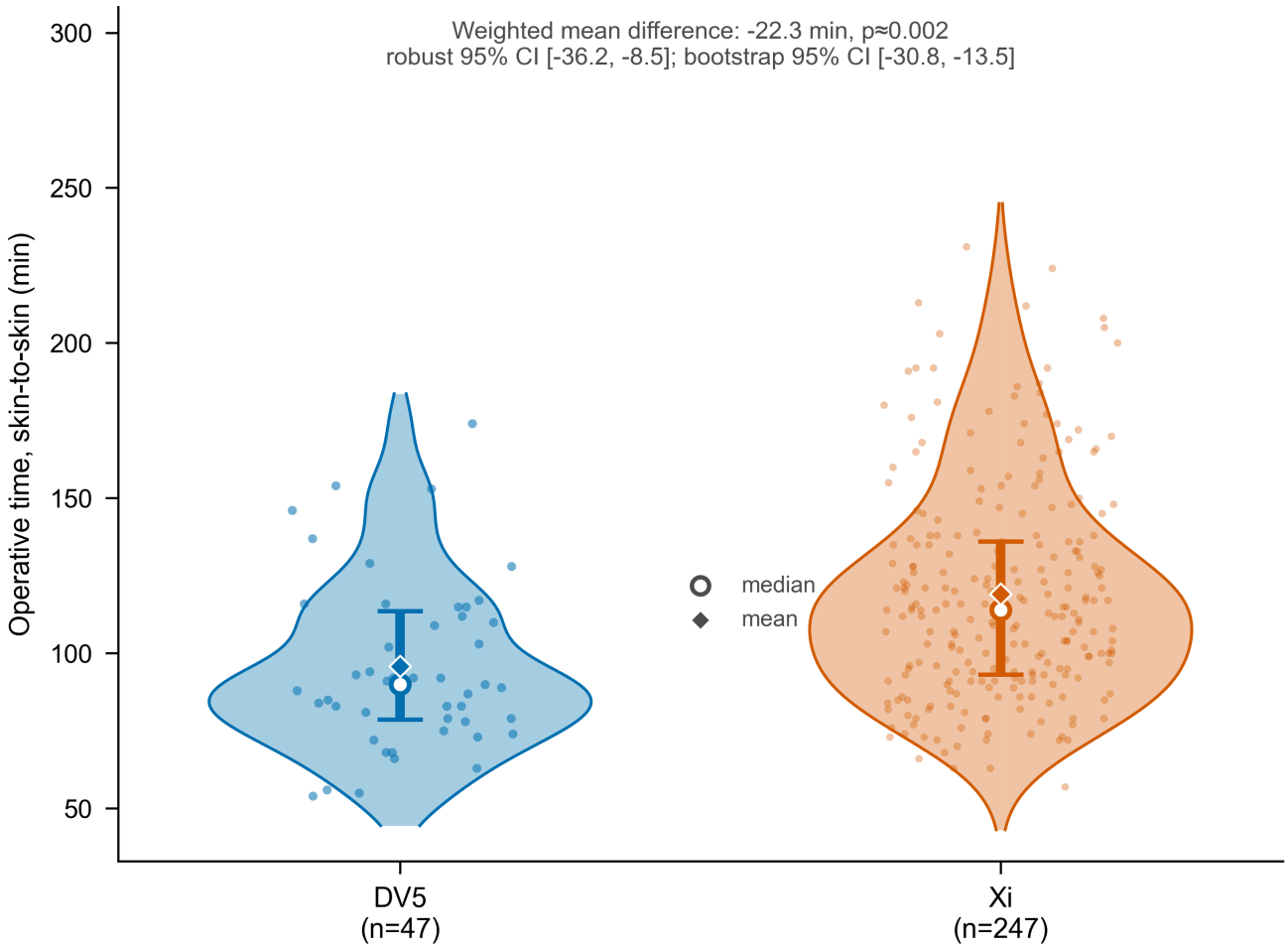


Figure 5

Operative time by platform.

Supplementary Files

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- SupplementaryFigureS1.png
- SupplementaryTableS1.docx
- SupplementaryTableS2.docx