

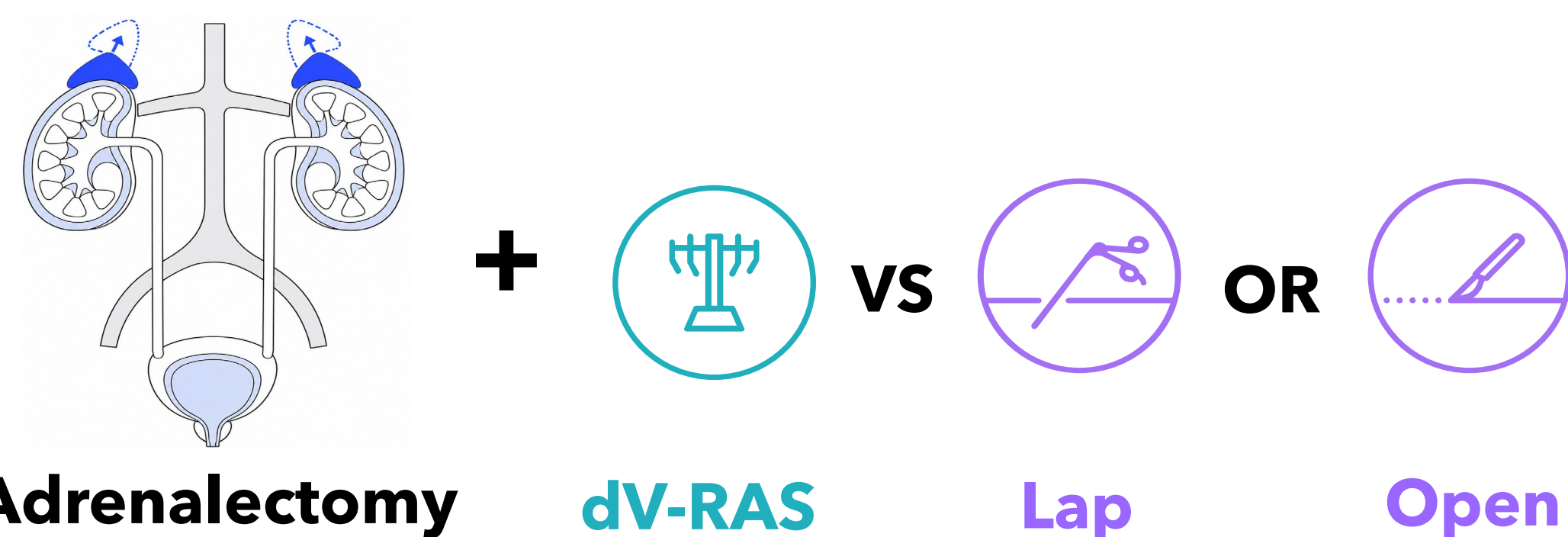
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INTRODUCTION

- Despite growing utilization of da Vinci surgical system (dV-RAS), the comparative evidence versus laparoscopic (Lap) and Open adrenalectomy remains fragmented and heterogeneous.
- Most published studies are retrospective single-center analyses with small sample sizes, heterogeneous populations, and inconsistent perioperative outcome reporting, highlighting the need for a systematic literature review and meta-analysis to comprehensively evaluate the comparative surgical value of dV-RAS for benign adrenal disease.

AIM

This systematic review and meta-analysis compared perioperative and quality of life outcomes between dV-RAS, Lap, and Open approaches for benign adrenalectomy.



METHODS

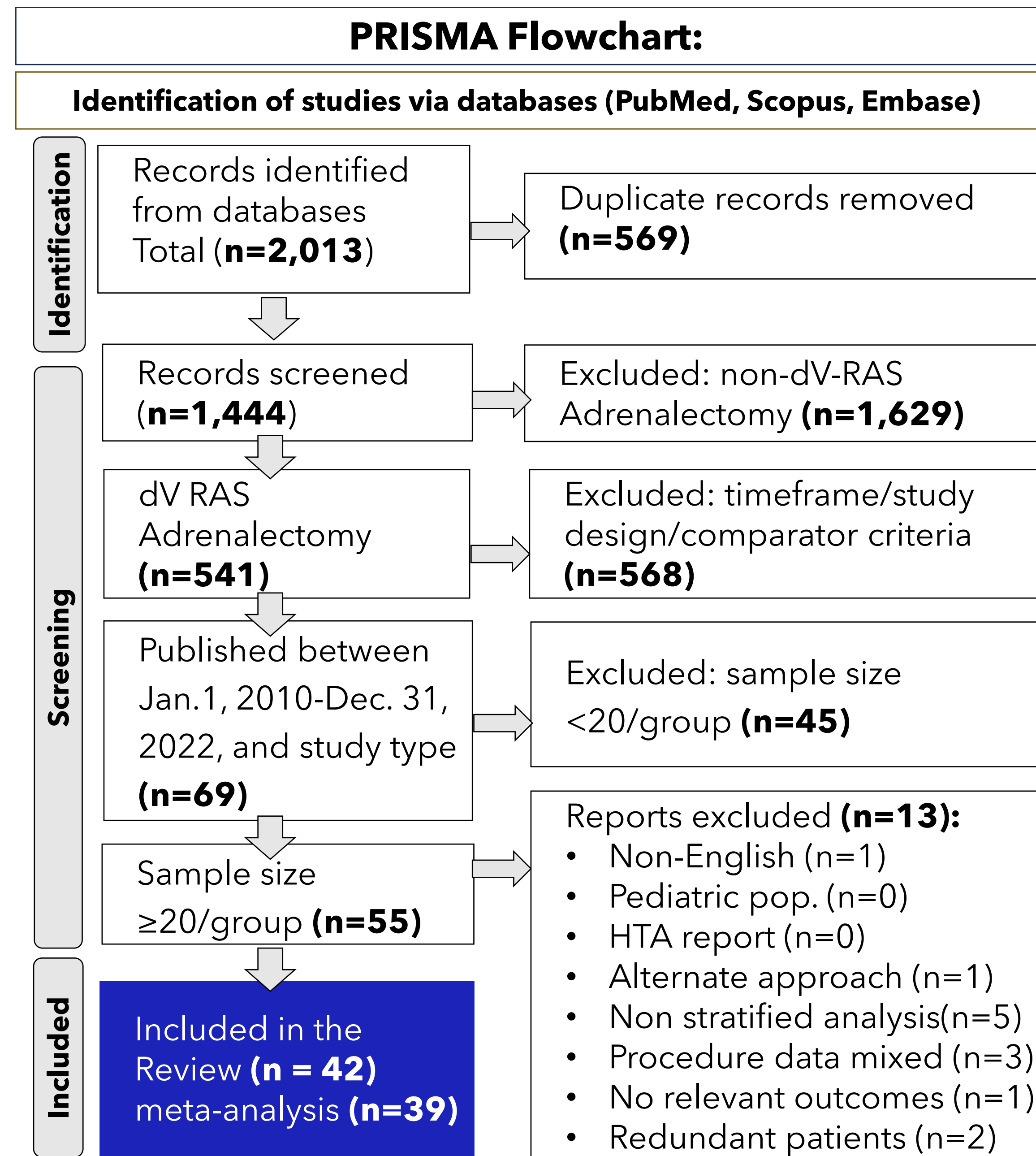
A PRISMA-guided systematic review and meta-analysis of studies identified from PubMed, Embase, and Scopus over a 14-year period compared dV-RAS with Lap and Open adrenalectomy.

P	Adults undergoing adrenalectomy for ≥80% benign indications
I	dV-RAS adrenalectomy
C	Lap and Open adrenalectomy
O	Pheochromocytoma of the Adrenal gland Scaled Score (PASS score), conversion rate, operative time, estimated blood loss, blood transfusions, length of hospital stay, intraoperative complications, hemodynamic instability, 30-day Outcomes (postoperative complications, hemoglobin levels, surgical site infections, Visual Analog Score (VAS) pain score, pain medication, reoperations, readmissions, mortality), recurrence rate, return to work (RTW) and activities of daily living (ADL)
T	January 1, 2010 - December 31, 2024
S	Randomized controlled trials (RCTs), prospective, database and retrospective cohort studies with sample size >20 in each cohort

P: Population; I: Intervention; C: Comparator; O: Outcomes; T: Timeframe; S: Study design

- Meta-analysis was conducted in R (Meta package). A random model was used for heterogeneity of I²>50%.
- Subgroup analyses were performed for unilateral adrenalectomy, pheochromocytoma, large tumors (≥5 cm), and obesity (BMI≥30kg/m²).

RESULTS



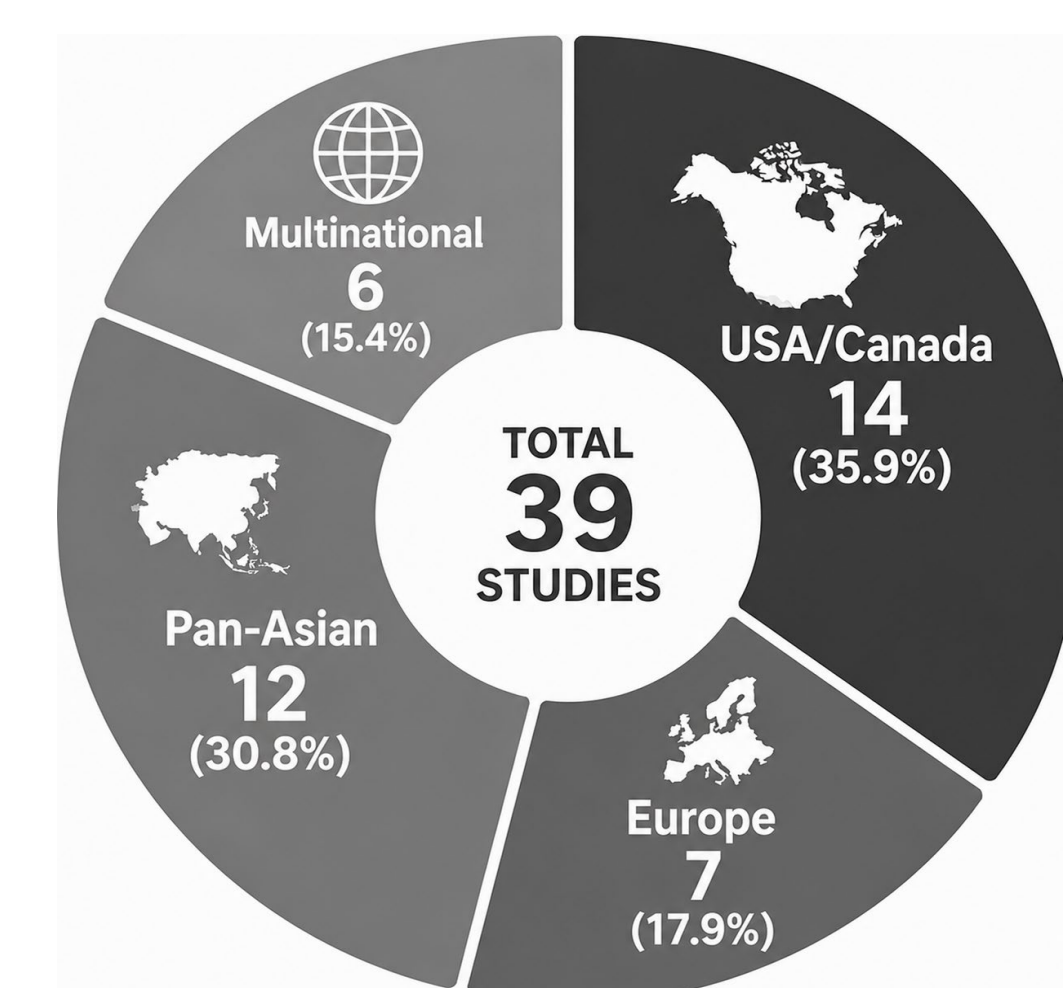
39 publications on benign adrenalectomy

- 5,087 dV-RAS patients
- 11,376 Lap patients
- 1,392 Open patients

Level of Evidence: No. Studies (%)

- 1 (2.6%) Randomized controlled trials
- 4 (10.2%) Large database studies
- 34 (87.2%) Retrospective cohort studies

Geographic distribution: No. Studies (%)



RESULTS

Outcome	No. of studies (n)	dV-RAS (n)	Lap/Open (n)	Effect size	p-value	Heterogeneity	Conclusion
PASS score	3	153	199	MD: -0.23 [-1, 0.54]	0.56	I ² = 60.52%; p=0.08*	Comparable
Conversion rate (%)	23	2083	2772	OR: 0.55 [0.33, 0.92]	0.02	I ² = 8.15%; p=0.36	45% less likely
Intraoperative complications (%)	10	609	1028	OR: 0.61 [0.37, 1.00]	0.05	I ² = 0.00%; p=0.52	Comparable
Estimated blood loss (mL)	22	1797	2207	MD: -23.18 [-34.71, -11.64]	<0.01	I ² = 89.13%; p<0.01*	23mL less
Blood transfusions (%)	8	621	860	OR: 0.66 [0.38, 1.13]	0.13	I ² = 0.00%; p=0.57	Comparable
Hemodynamic instability (mmHg)	3	179	312	MD: 2.09 [-0.27, 4.44]	0.08	I ² = 0.00%; p=0.65	Comparable
Operative time (minutes)	27	2076	2618	MD: -1.53 [-10.73, 7.67]	0.75	I ² = 87.02%; p<0.01*	Comparable
Length of hospital stay (days)	27	2139	3252	MD: -0.42 [-0.81, -0.03]	0.04	I ² = 89.06%; p<0.01*	0.42days less
Postop hemoglobin change (g/dl)	2	81	146	MD: -0.17 [-0.76, 0.41]	0.56	I ² = 74.78%; p=0.05*	Comparable
30-day VAS pain score	4	110	149	MD: -0.06 [-0.46, 0.34]	0.77	I ² = 60.46%; p=0.06*	Comparable
30-day complications (%)	16	3165	4574	OR: 0.76 [0.47, 1.22]	0.26	I ² = 73.49%; p<0.01*	Comparable
30-day readmission (%)	5	327	437	OR: 1.09 [0.36, 3.32]	0.88	I ² = 0.00%; p=0.60	Comparable
30-day reoperation (%)	2	145	153	RD: 0.0000 [-0.0183, 0.0183]	1.00	I ² = 0.00%; p=1.00	Comparable
30-day mortality (%)	9	981	2414	RD: -0.0009 [-0.0074, 0.0057]	0.80	I ² = 0.00%; p=0.99	Comparable
Recurrence rate (%)	2	179	162	RD: 0.0000 [-0.0198, 0.0198]	1.00	I ² = 0.00%; p=1.00	Comparable
Estimated blood loss (mL)	2	136	57	MD: -337.08 [-417.08, -257.07]	<0.01	I ² = 10.44%; p=0.29	337mL less
Blood transfusions (%)	2	136	57	OR: 0.08 [0.01, 0.49]	0.01	I ² = 54.15%; p=0.14*	92% less likely
Operative time (minutes)	2	136	57	MD: -69.94 [-226.74, 86.86]	0.38	I ² = 97.88%; p<0.01*	Comparable
Length of hospital stay (days)	2	136	57	MD: -4.34 [-5.68, -3]	<0.01	I ² = 47.40%; p=0.17	4.32days less
30-day complications (%)	2	1740	994	OR: 0.44 [0.12, 1.64]	0.22	I ² = 62.53%; p=0.10*	Comparable
30-day mortality (%)	3	468	395	RD: 0.0000 [-0.0089, 0.0089]	1.00	I ² = 0.00%; p=1.00	Comparable

Bold values are statistical significance, P <0.05; Inverse Variance (IV) Fixed model used for all the outcomes EXCEPT those denoted by (*) for which random model was used. Outcomes not reported in this table had insufficient data.

Table 2: Sub-group analysis: dV-RAS versus Laparoscopic benign adrenalectomy

1. Unilateral Adrenalectomy (11 Studies)	2. Pheochromocytoma (9 Studies)	3. Large tumor size (≥ 5cm) (6 Studies)	4. Obese (BMI≥30kg/m ²) (4 Studies)
↓ 30-day postoperative complications by 69%	↓ Conversion to open surgery by 73%	↓ Estimated blood loss by 68.7 mL	↓ Estimated blood loss by 44.9 mL
= Conversion to open surgery = Estimated blood loss = Blood transfusions = Intraoperative complications = Operative time = Length of stay = 30-day mortality	= PASS score = Conversion to open surgery = Estimated blood loss = Blood transfusions = Intraoperative complications = Hemodynamic instability = Operative time = Length of stay = 30-day mortality	= Conversion to open surgery = Blood transfusions = Intraoperative complications = Operative time = Length of stay	= Conversion to open surgery = Operative time = Length of stay = 30-day postoperative complications = 30-day mortality

Outcomes not shown in this table had insufficient subgroup level data; there was insufficient data to pool robotic versus open comparison

CONCLUSIONS

- dV-RAS was associated with lower blood loss and shorter length of stay versus both comparator approaches, with fewer conversions to laparotomy versus Lap and lower transfusion rates versus open surgery.
- Across diverse patient populations, dV-RAS demonstrates consistent improved or comparable perioperative advantages compared to Lap in benign adrenalectomy.
- Future high-quality comparative studies evaluating perioperative, functional, and quality-of-life outcomes are warranted.

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TABLES & REFERENCES

