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Brief Report

Hospital Volume as a Determinant of Outcomes After Partial Nephrectomy: A Systematic Review by the European Association of Urology Renal Cell Carcinoma Guidelines Panel

Lorenzo Marconi^{a,*}, Teele Kuusk^b, Milan Hora^c, Tobias Klatter^d, Saaed Dabestani^{e,f}, Umberto Capitanio^{g,h}, Yasmin Abu-Ghanemⁱ, Riccardo Campi^j, Sergio Fernández-Pello^k, Laurence Albiges^l, Jens Bedke^{l,m,n}, Thomas Powles^o, Alessandro Volpe^p, Börje Ljungberg^q, Axel Bex^{r,s,t}

^a Department of Urology and Renal Transplantation, Unidade Local de Saúde de Coimbra, Coimbra, Portugal; ^b Department of Urology, Darent Valley Hospital, Dartford and Gravesham NHS Trust, Dartford, UK; ^c Department of Urology, University Hospital Pilsen and Faculty of Medicine in Pilsen, Charles University, Czechia; ^d Department of Urology, Helios Hospital Bad Saarow, Bad Saarow, Germany; ^e Department of Urology, Kristianstad Central Hospital, Kristianstad, Sweden; ^f Department of Translational Medicine, Division of Urological Cancers, Lund University, Lund, Sweden; ^g Department of Urology, San Raffaele Scientific Institute, Milan, Italy; ^h Division of Experimental Oncology/Unit of Urology, Urological Research Institute, IRCCS San Raffaele Hospital, Milan, Italy; ⁱ Guy's and St. Thomas' NHS Foundation Trust, London, UK; ^j Unit of Urologic Robotic Surgery and Renal Transplantation, Careggi University Hospital, Florence, Italy; ^k Department of Urology, Cabueñas University Hospital, Gijón, Spain; ^l Department of Cancer Medicine, Gustave Roussy, Université Paris-Saclay, Villejuif, France; ^m Department of Urology, University Hospital Tübingen, Tübingen, Germany; ⁿ German Cancer Consortium and German Cancer Research Center, Heidelberg, Germany; ^o Royal Free NHS Trust and Barts Cancer Institute, Queen Mary University of London, London, UK; ^p Department of Urology, University of Eastern Piedmont, Maggiore della Carità Hospital, Novara, Italy; ^q Department of Surgical and Perioperative Sciences, Urology and Andrology, Umeå University, Umeå, Sweden; ^r Royal Free London NHS Foundation Trust, London, UK; ^s Division of Surgery and Interventional Science, University College London, London, UK; ^t Department of Urology, Netherlands Cancer Institute, Antoni van Leeuwenhoek Hospital, Amsterdam, The Netherlands

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Abstract

The influence of surgical volume on partial nephrectomy (PN) outcomes is a subject of debate. The European Association of Urology (EAU) renal cell carcinoma (RCC) guideline panel performed a protocol-driven systematic review of the association between hospital volume (HV) and oncological, functional, and complication outcomes following PN for RCC. The intervention was PN performed in a higher-volume hospital (defined according to the number of procedures per unit time) and the comparator was PN performed in a lower-volume hospital. Ten studies involving a total of 106 569 patients were included in the review. Higher HV was associated with lower complication rates, shorter length of stay, lower positive surgical margin rates, and lower transfusion rates. For six studies, multivariable analyses showed that low HV was an independent risk factor for inpatient complications, PSM presence, longer LOS, and failure to achieve a trifecta of no complications, warm ischemia time <25 min, and negative surgical margins. Most studies were judged to have high risk of bias. The available evidence suggests a potential association between higher HV and better PN outcomes in RCC. The EAU RCC guidelines panel

* Corresponding author. Department of Urology and Renal Transplantation, Unidade Local de Saúde de Coimbra, Praceta Professor Mota Pinto, Celas, 3004-561 Coimbra, Portugal.
E-mail address: lorenzooliveiramarconi@gmail.com (L. Marconi).

Partial nephrectomy
Learning curve

encourages the development and rigorous evaluation of indicators of surgery quality in RCC to better inform the designation of high-quality centers within models of centralized care.

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ADVANCING PRACTICE

What does this study add?

There is growing evidence of an association between higher hospital volume (HV) and better cancer outcomes. The influence of surgical volume on partial nephrectomy (PN) outcomes is still a matter of debate. Our study is the most comprehensive and up-to-date systematic review of the association between HV and PN outcomes. The available evidence suggests a potential association between higher HV and better PN outcomes in renal cell carcinoma, although this finding should be interpreted with caution given the limitations in the quality of the evidence.

Clinical Relevance

Subspecialisation is one of the key elements in optimising surgical outcomes. In this study, the authors performed a systematic review to evaluate the impact of hospital volume on partial nephrectomy outcomes. The authors found that higher hospital volume was associated with lower complication rates, better peri-operative outcomes, and lower positive surgical margin rates. This is an important evidence to encourage designation of high-quality centres for centralised care in the future. Associate Editor: Jeremy Y.C. TEOH, MD.

Patient Summary

We reviewed the literature to assess the association between hospital caseload for partial kidney removal for kidney cancer and patient outcomes. The best outcomes were observed for patients treated at higher-volume hospitals.

To improve the quality of care, there has been growing promotion of public policies supporting centralization of cancer care to higher-volume hospitals [1]. In part, this is because of increasing evidence showing an association between higher hospital volume (HV) and better cancer outcomes [2]. Surgical care for genitourinary malignancies in higher-volume hospitals has been associated with lower morbidity and better survival outcomes [3], especially in the setting of complex surgical procedures such as radical cystectomy [4]. For renal cell carcinoma (RCC) there are very few data indicating an association between higher HV and lower overall mortality after radical nephrectomy (RN) [5]. The influence of surgical volume on partial nephrectomy (PN) outcomes is still a matter of debate. We set out to evaluate the evidence base concerning the impact of HV on PN outcomes via a systematic review and narrative synthesis of the literature.

We performed a protocol-driven systematic review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and in accordance with the principles outlined in the Cochrane Handbook for Systematic Reviews of Interventions [6,7]. The search strategy and PICO (Population, Intervention, Comparator, Outcome) elements are outlined in the [Supplementary material](#). In brief, comparative studies involving patients with localized RCC treated with PN at lower- or

higher-volume hospitals reporting on oncological, functional, or perioperative outcomes that were published between January 2000 and March 2024 were included. We defined HV as the total number of nephrectomies performed at each institution per year, with the cutoff for the various volume categories determined by the primary investigators of the individual studies. Risk of bias (RoB) was assessed using the ROBINS-I tool [8]. Owing to clinical heterogeneity, data were summarized narratively.

Ten studies involving a total of 106 569 patients were eligible for inclusion [9–18]. All of the studies were nonrandomized comparative studies that used large multicenter databases (US Nationwide Inpatient Sample, five studies; French NEPHRON database, 1 study; French Committee of Urologic Oncology, one study; Italian RECORD 2 project, one study; UK British Association of Urological Surgeons nephrectomy audit, one study; and US National Cancer Data Base, one study). The results are shown in [Tables 1 and 2](#). [Supplementary Fig. 1](#) and [Supplementary Table 1](#) show the PRISMA flow diagram and RoB assessment, respectively. There was substantial heterogeneity across studies in the definition of cutoffs for volume categories. The highest-volume group varied from ≥ 16 procedures [10] to ≥ 100 procedures [16] per year. Overall, the median cutoff for the highest-volume group across studies was 42 PN/yr (interquartile range 18–65).

On univariable analysis, the highest HV in comparison to the lowest HV was associated with lower rates of complica-

Table 1 – Study characteristics

Study and setting	PNs (n) and approach	Period	Volume cutoff definition	Volume groups (intervention and comparators)	Age (yr)	PN outcomes and methods used	
Arora 2018 [9] USA NIS	8753 OPN/RAPN	2008–2011	HV quartiles (PN/yr)	Low	1–11 PN/yr	59.4 (49.9–66.9) ^a	UVA: any IPC, major IPCs, specific complications, LOS, BT, total costs MVA: any and major IPC (adjusted for age, race, sex, insurance status, CCI, income quartiles)
				ITM	12–27 PN/yr	59.2 (49.9–66.9) ^a	
				High	27–64 PN/yr	58.3 (49.9–66.6) ^a	
Becker 2014 [10] USA NIS	42 168 OPN and MIS PN	1998–2007	HV tertiles (PN + RN/yr)	Highest	≥64 PN/yr	59.2 (50.2–67.1) ^a	UVA: IOCs, POCs, BT, LOS ≥5 d, IHM
				Low	1–5 NY/yr	63 (53–72) ^a	
				ITM	6–15 NY/yr		
Couapel 2013 [18] France NEPHRON database 53 centers	570 OPN, LPN, RAPN	2010 (Jun–Dec)	HV quintiles (PN/6 mo)	Low	Merged <2 and 3–4 PN/6 mo	63 (32–81) ^b	UVA: OT, EBL, Hb decrease, WIT, LPN → OPN, PN/RN ratio, LOS, PSM rate, mortality rate MVA: predictors of PSM and complications
				ITM	5 and 9 PN/ 6M	64 (21–85) ^b	
				High	10 and 18 PN/6 mo	62 (26–84) ^b	
Monn 2014 [11] USA NIS	17 583 RAPN only	2009–2011	HV tertiles in 2009, 2010, and 2011 (RAPN/yr)	Highest	19 and 53 PN/6 mo	59 (21–90) ^b	UVA: in-hospital complications, BT, LOS, hospital costs MVA: POCs
				Low	2009: 4–13 RAPN/yr 2010: 4–14 RAPN/yr 2011: 5–13 RAPN/yr	56.0	
				ITM	2009: 14–34 RAPN/yr 2010: 14–38 RAPN/yr 2011: 14–40 RAPN/yr	58.4	
Peyronnet 2018 [12] France French Committee of Urologic Oncology 11 centers	1222 RAPN only	2009–2015	HV quartiles (RAPN/yr)	High	2009: >35 RAPN/yr 2010: >39 RAPN/yr 2011: >41 RAPN/yr	58.0	UVA: trifecta (no complications, WIT <25 min, and NSM), POCs (CD), OT, LOS, EBL, hemorrhage MVA: trifecta
				Low	<20 RAPN/yr	58.5 (13.5) ^c	
				ITM	20–44 RAPN/yr	59.1 (12.1) ^c	
Schiavina 2020 [13] Italy RECORD 2 project 26 centers	2076 OPN, LPN, RAPN	2013–2016	MRD PN/yr	Highest	>70 RAPN/yr	60.7 (11.9) ^c	MVA: PSM rate
				Low	<60 PN/yr	62 (54–72) ^a	
				ITM	20–44 RAPN/yr	59.1 (12.1) ^c	
Sun 2012 [14] USA NIS	8671 PN	1998–2007	HV quartiles RN+PN/yr	High	> 60 PN/yr		UVA: POCs, LOS, IHM
				Low	1–5 NY/yr	NR	
				ITM	6–15 NY/yr		
Taub 2003 [15] USA NIS, 962 centers	1172 PN	1993–1997	HV tertiles RN + PN + NU/yr	High	≥16 NY/yr		UVA: IHM, LOS
				Low	1–14 NY/yr	NR	
				ITM	15–33 NY/yr		
				High	≥34 NY/yr		

Table 1 (continued)

Study and setting	PNs (n) and approach	Period	Volume cutoff definition	Volume groups (intervention and comparators)	Age (yr)	PN outcomes and methods used
Tran 2020 [16] UK British Association of Urological Surgeons nephrectomy audit	5630 PN	2012–2016	Arbitrary definition PN + RN/yr for cT1 and PNs/yr	Low 1–2 NY/mo	NR	Logistic regression used to model the probability of CD grade ≥III complications as a function of annual PN volume per hospital
Xia 2017 [17] USA NCDB	18 724 RAPN only	2010–2013	Quintiles PN/yr	ITM High Highest Low Low-ITM ITM-high High Highest	60 (51–67) ^a 60 (51–68) ^a 60 (51–68) ^a 60 (51–68) ^a 59 (50–67) ^a	UVA and MVA: 30-d + 90-d mortality, open conversion, prolonged LOS, 30-d unplanned readmission, PSM rate

PN = partial nephrectomy; LPN = laparoscopic PN; OPN = open PN; RAPN = robot-assisted PN; MIS = minimally invasive surgery; RN = radical nephrectomy; NY = nephrectomy; LOS = length of stay; UVA = univariable analysis; MVA = multivariable analysis; BAUS = British Association of Urological Surgeons; BT = blood transfusion; CCI = Charlson comorbidity index; CD = Clavien-Dindo; EBL = estimated blood loss; Hb = hemoglobin; HV = hospital volume; IHM = in-hospital mortality; IOC = intraoperative complication; IPC = inpatient complication; ITM = intermediate; MRD = Martingale residuals to determine the best cutoff for low vs high volume; NCDB = National Cancer Data Base; NS = National Inpatient Sample; NR = not reported; NSM = negative surgical margin; NU = nephroureterectomy; OT = operating time; POC = postoperative complication; PSM = positive surgical margin; WIT = warm ischemia time

^a Median (interquartile range).
^b Mean (range).
^c Mean (standard deviation).

tions in four studies [9,10,12,14], shorter length of stay (LOS) in eight studies [9–12,14,15,17,18], lower positive surgical margin (PSM) rates in three studies [12,17,18], and lower transfusion rates in four studies [9–11,14]. Six studies presented multivariable analyses, which showed that HV was an independent risk factor for inpatient complications in three studies [9,11,16], trifecta achievement (no complications, warm ischaemia time <25 min, and negative surgical margins) in one study [12], PSM in one study [13], and longer LOS and conversion to open surgery in one study [17]. Conversely, multivariable analysis in the study with the smallest sample size indicated that HV was not an independent predictor of PSM or surgical complications [18]. In the three studies focusing exclusively on robot-assisted PN (RAPN) [11,12,17], higher HV (defined as >41 [11], >44 [17], and >70 [12] RAPN/yr) was associated with better perioperative outcomes and lower PSM rates (Table 2). There were no data on overall survival, cancer-specific survival, or disease-free survival (Table 2). Most studies were judged to have high RoB. Analyses were flawed by the absence of control for important confounders such as patient, tumor, and surgeon characteristics, and the PN approach, which could ultimately influence PN outcomes [19,20]. The HV cutoff values were also very heterogeneous (arbitrarily defined as tertiles, quartiles, or quintiles), which consequently precludes the definition of a meaningful minimal PN volume for safe surgical practice. Older studies included in the current review may not reflect current practice and HV magnitudes.

The correlation between surgical HV and PN outcomes may be because of improvements in the technical experience of the surgical team, streamlined perioperative protocols, and access to multidisciplinary preoperative and postoperative care. In this context, HV is a very complex variable that seems to have more of an impact on PN outcomes than surgeon volume does [12]. Apart from better PN outcomes, treatment in higher-volume centers appears to be associated with closer adherence to guidelines regarding the management of T1 RCC, with more frequent use of PN instead of RN [16,18,21,22]. There are further unmeasured outcomes that would benefit from centralization of care, such as education, training, and research [23]. We acknowledge that limited patient access to care because of geographic and financial constraints, and de-skilling of health professionals in lower-volume centers are criticisms of centralization policies [24].

There is considerable heterogeneity of RCC centralization policies across Europe. According to a survey performed by the EAU RCC guidelines panel, very few national societies or national health governance bodies mandate a minimum annual number of PN or RN procedures needed to provide specialist treatment for kidney cancer (Table 3). In most countries, these numbers are only considered as quality measures and are not legally required to perform kidney cancer surgery. Current data are inadequate for drawing any strong and clear conclusions regarding a cutoff value to define high HV. When setting a minimum volume number, the focus should shift to validated RCC-specific quality indicators, emphasizing the concept of a high-quality center over a high-volume center. Some of the validated RCC-

Table 2 – Summary of study results

Study	Univariable analysis			Multivariable analysis			
	Outcome	Volume groups ^a C vs I ₁ vs I ₂ vs I ₃	p value	Outcome	Odds ratio (95% CI)	Covariates	
Arora [9]	Any IPC (%)	25.6 vs 21.4 vs 16.7 vs 17.9	<0.001	Any IPC Major IPC	Significant inverse nonlinear association between HV and IPCs (<i>p</i> < 0.001)	Age, race, sex, ISS, CCI, IQs	
	Major IPCs (%)	12.8 vs 9.9 vs 7.3 vs 7.8	<0.001				
	LOS (d)	3.4 vs 3.0 vs 2.7 vs 2.8	<0.001				
	BT rate (%)	12.3 vs 10.2 vs 7.6 vs 9.0	0.002				
	Total costs (US\$)	12 981 vs 13 743 vs 13 511 vs 14 579	<0.001				
Becker [10]	IOC rate (%)	2.8 vs 3.3 vs 2.6	0.2				
	POC rate (%)	16.9 vs 15.8 vs 13.8	0.004				
	BT (%)	10.3 vs 9.4 vs 8.0	0.007				
	LOS ≥5 d (%)	49.0 vs 46.5 vs 41.8	<0.001				
	IHM (%)	0.3 vs 0.5 vs 0.4	0.5				
Couapel [18]	OT (min)	144.6 vs 150.7 vs 147.4 vs 145.3	0.62	PSM	HV not independent predictor	Not reported	
	EBL (ml)	246 vs 335 vs 277 vs 273	0.16	SCs	HV not independent predictor	Not reported	
	Hb decrease (g/dl)	2.21 vs 2.12 vs 1.92 vs 1.65	0.005				
	WIT (min)	22 vs 20 vs 18 vs 20	0.021				
	LPN → OPN (%)	0 vs 1.4 vs 3.9 vs 7.1	0.058				
	PN/RN ratio (%)	2.1 vs 5.4 vs 1.7 vs 1.1	0.128				
	LOS (days)	9 vs 9.2 vs 8.5 vs 7.6	0.001				
	PSM (%)	7 vs 16 vs 8 vs 6	0.001				
	Mortality (%)	0 vs 0 vs 0.5 vs 1.1	0.82				
	Monn [11]	Perioperative BT (%)	9 vs 8 vs 5	0.015	IHC	0.58 (0.37–0.90) ^c	Age, gender, region, hospital, type, payer, comorbidities, kidney cancer
Any complication (%)		15 vs 12 vs 10	0.071				
LOS (d)		3 vs 3 vs 3	0.002				
Cost (US\$)		14, 287 vs 14,410 vs 13,956	0.09				
Trifecta rate (%) ^b		60.3 vs 72.3 vs 86.2 vs 82.4	<0.001	Trifecta rate ^b	3.7 (2.11–6.6) ^d 4.42 (2.54–7.55) ^e 1.8 (1.15–2.84) ^e	Tumor size, RENAL score, surgeon experience and volume	
Peyronnet [12]	PSM (%)	10.5 vs 5.6 vs 5.6 vs 3.6	0.02				
	WIT (min)	20.3 vs 16.6 vs 15.4 vs 14	<0.001				
	OCs (%)	19.6 vs 19.1 vs 12.5 vs 17.5	0.11				
	CDCs ≥III (%)	12.1 vs 7.6 vs 4.2 vs 5.2	0.01				
	OT (min)	181.3 vs 158.4 vs 149.6 vs 131	<0.001				
	LOS (d)	6 vs 4.2 vs 4.7 vs 4	<0.001				
	EBL (ml)	285 vs 270 vs 234 vs 323	0.04				
	HCs (%)	3.2 vs 3.7 vs 2.5 vs 5.4	0.77				
	Schiavina [13]				PSM	Low vs high HV: 2.22 (1.55–3.18)	Age, ASA, CCI, indication, T stage, PADUA, ischemia type, approach, nuclear grade, upstaged pT3a
Sun [14]	BT (%)	5 vs 6 vs 4	0.006				
	POCs (%)	14 vs 14 vs 11	0.003				
	LOS >5 d (%)	28 vs 25 vs 22	0.006				
	IHM (%)	1 vs 0 vs 0	0.2				
Taub [15]	IHM (%)	2.25 vs 0.57 vs 0.36	0.018				
	LOS (d)	7.97 vs 7.43 vs 7.06	0.001				
Tran [16]				CDCs ≥III	Complication rates decreased with increasing HV; RCRS used to model CDC ≥III probability with annual PN volume (<i>p</i> = 0.012)	PADUA	
Xia [17]	30-d mortality	0.2 vs 0.4 vs 0.4 vs 0.3 vs 0.1	0.151	Conversion	0.47 (0.34–0.66) ^f ; <i>p</i> < 0.001	Age, sex race, CCI, ISS, education, income, year, Fuhrman grade, histology, size	
	90-d mortality	0.3 vs 0.5 vs 0.5 vs 0.4 vs 0.3	0.347	Prolonged LOS	0.45 (0.4–0.51) ^f ; <i>p</i> < 0.001		
	Conversion	3.1 vs 2.7 vs 1.9 vs 1.7 vs 1.4	<0.001	30-d REA	0.99 (0.75–1.30) ^f ; <i>p</i> = 0.945		

Table 2 (continued)

Study	Univariable analysis			Multivariable analysis		
	Outcome	Volume groups ^a C vs I ₁ vs I ₂ vs I ₃	p value	Outcome	Odds ratio (95% CI)	Covariates
	Prolonged LOS	26.2 vs 25.7 vs 21.7 vs 18.7 vs 14.9	<0.001	PSM	0.34 (0.28–0.41) ^f	p < 0.001
	30-d REA	2.8 vs 3.5 vs 3.2 vs 2.3 vs 3.0	0.024			
	PSM	11.8 vs 9.5 vs 9.4 vs 7.5 vs 4.6	<0.001			

→ = conversion; ASA = American Society of Anesthesiologists score; BT = blood transfusion; CCI = Charlson comorbidity index; CDCs = Clavien-Dindo complications; Hb = hemoglobin; HCs = hemorrhage complications; IHM = in-hospital mortality; IPC = inpatient complication; IQs = income quartiles; ISS = insurance status; LOS = length of stay; PSM = positive surgical margin; OCs = overall complications; OR = odds ratio (with 95% confidence interval); OT = operating time; PN = partial nephrectomy; LPN = laparoscopic PN; OPN = open PN; POCs = postoperative complications; HV = hospital volume; EBL = estimated blood loss; REA = readmission; RCSR = restricted cubic spline regression; SCs = surgical complications; WIT = warm ischemia time.

^a Volume groups as defined in Table 1: C = control (lowest-volume group); I₁ = intervention 1 (intermediate-volume group); I₂ = intervention 2 (high-volume group); I₃ = intervention 3 (highest-volume group)

^b Trifecta: no complications, WIT <25 min, and negative surgical margin.

^c High HV vs low HV.

^d Very high HV vs low HV.

^e Moderate HV vs low HV.

^f Very high HV vs very low HV.

Table 3 – Volume “standards” for partial nephrectomy defined across European countries

Country	Volume “standard”	Authority
Croatia	No standard defined	
Czechia	No standard defined	
Denmark	35 RN or PN/yr (only 8 hospitals perform RCC surgery, only 7 perform PN)	National health governing body
Estonia	No standard defined	
Finland	35 PN/yr	
France	No standard defined	
Germany	Total of 40 PN/RN procedures as the first surgeon within the last 3 yr for certification as a kidney cancer surgeon; minimum of 15 cases/yr to remain certified; minimum of 2 surgeons required for each center	OnkoZert/German Cancer Society
Italy	No standard defined	
Lithuania	No standard defined	
Netherlands	Minimum number is 10 PN/yr per hospital (mean over a period of 3 yr; 2018 Dutch volume norm)	Dutch Association of Urology
Norway	Minimum annual number of RCC surgeries (RN/PN) is 20 procedures per hospital and 10 per surgeon	National health governing body
Portugal	No standard defined	
Spain	No standard defined	
Sweden	Kidney cancer surgery should be performed in centers with a volume of >25 operations/yr for 90% of all patients, and in centers with a volume of >50 operations/yr for 50% of all patients	Regional cancer center/national health authority
Slovakia	No standard defined	
Slovenia	No standard defined	
UK	No standard defined	

PN = partial nephrectomy; RCC = renal cell carcinoma; RN = radical nephrectomy.

specific quality indicators that could be considered include: (1) the proportion of T1a tumors managed with PN; (2) the proportion of T1–2 tumors for which a minimally invasive RN approach (laparoscopic or robotic) is used; (3) the PSM rate following PN for T1 tumors; and (4) the 30-d unplanned readmission rate after PN. Such quality indica-

tors should be used as a benchmarking tool for RCC surgery to provide audit-level feedback to hospitals and policymakers for quality improvement [25].

In conclusion, the available evidence suggests a potential association between higher HV and better PN outcomes in RCC, although this finding should be interpreted with caution given the limitations in the quality of the evidence. In addition, volume recommendations issued by professional associations are largely absent in Europe, and where present, differ considerably between countries. The EAU RCC guidelines panel encourages the development and rigorous evaluation of indicators of surgical quality in RCC to better inform the designation of high-quality centers within models of centralized care.

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Study concept and design: Marconi, Bex.

Acquisition of data: Marconi, Kuusk, Bex, Hora, Ljungberg.

Analysis and interpretation of data: Marconi, Bex.

Drafting of the manuscript: Marconi, Bex.

Critical revision of the manuscript for important intellectual content: Marconi, Kuusk, Hora, Klatte, Dabestani, Capitanio, Abu-Ghanem, Campi, Fernández-Pello, Albiges, Bedke, Powles, Volpe, Ljungberg, Bex.

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Appendix A. Supplementary data

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