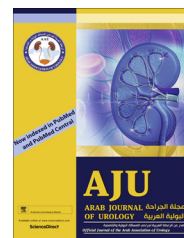




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LAPAROSCOPY/ROBOTICS
REVIEW

Laparoscopic vs robotic nephroureterectomy: Is it time to re-establish the standard? Evidence from a systematic review



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KEYWORDS

Nephroureterectomy;
Robotic;
Laparoscopic;
Ureteric neoplasm
ureter

ABBREVIATIONS

CEBM, Centre for
Evidence-Based Medi-
cine;
EBL, estimated blood
loss;

Abstract Objective: To conduct a systematic review of comparative studies of laparoscopic nephroureterectomy (LNU), the standard management for upper urothelial tumours, and robot-assisted NU (RANU) that has emerged as a viable alternative.

Methods: MEDLINE, EMBASE and the Cochrane Library were searched according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to identify all studies reporting on both LNU and RANU for upper urothelial tract tumours.

Results: In all, 1630 patients were included, of which 838 underwent LNU and 792 RANU. Three studies reported on mean operative time and found it to be less in LNU, with two reporting this to be significant (RANU 298 vs LNU 251 min, $P = 0.03$; 306 vs 234 min, respectively, $P < 0.001$). Both studies reporting on median node count found this to be higher in the robotic groups: RANU 5.5 vs LNU 1.0 and RANU 21 vs LNU 11. Positive surgical margins (RANU 1.69% vs LNU

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LND, lymph node dissection;
 MeSH, Medical Subject Heading;
 OT, operative time;
 PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses;
 PSM, positive surgical margins;
 (L)(RA)NU, (laparoscopic) (robot-assisted) nephroureterectomy;
 VAS, visual analogue scale

7.06%, $P = 0.18$), bladder recurrence (24.6% vs 36.89%, $P = 0.09$), and distant metastases (27.50% vs 17.50%, $P = 0.29$) were not significantly different between the two techniques. Disease-specific mortality did not differ between the two techniques (RANU 7.5% vs LNU 12.5%, $P = 0.46$), but postoperative mortality was reduced in RANU (0.14% vs 1.32%, $P = 0.03$). Overall complication rates were statistically lower in RANU, at 12.5% vs 18.8% ($P < 0.001$).

Conclusions: This review suggests these techniques are equivalent in terms of perioperative and oncological performance. Furthermore, there may be a lower overall complication rate, as well as postoperative mortality in the robotic group. Further research in the form of a randomised controlled trial is warranted.

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Introduction

Upper urothelial tumours are rare but aggressive tumours and comprise only 5–10% of all urothelial malignancies [1–3]. The ‘gold standard’ for localised disease is radical nephroureterectomy (NU), with the laparoscopic technique considered the established standard [4,5]. However, this is still a challenging procedure laparoscopically due to the need for distal ureter dissection and bladder cuff excision. Many centres adopt a combined approach with laparoscopic NU (LNU) and an open ureterectomy and bladder cuff excision [6–8].

The introduction of robotic surgery with three-dimensional magnified vision and wrist action with a greater degree of freedom has the potential to offer a technically less challenging procedure and better reconstruction of the distal end [9]. Whether this translates into improved oncological or bladder recurrence outcomes are as yet unknown. Current literature on open NU and LNU suggests the technique used for the distal ureter and bladder cuff does not influence bladder recurrence or other oncological outcomes [10].

Therefore, we aimed to conduct a systematic review comparing LNU and robot-assisted NU (RANU) for the efficacy and safety of these two techniques.

Material and methods

The search strategy was conducted in accordance with Cochrane guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11]. A search strategy was conducted in MEDLINE, EMBASE and the Cochrane electronic databases (from 2000 to present) to identify studies that included both LNU and RANU. The search was conducted using the following keywords; ‘robotic’, ‘robot-assisted’, ‘laparoscopic’, ‘laparoendoscopic’, ‘nephroureterectomy’ and ‘urothelial carcinoma’. Medical Subject Heading (MeSH) phrases included: (‘Ureteral Neo-

plasms’[MeSH]) AND (‘Laparoscopy’[MeSH]), (‘Ureteral Neoplasms’[Mesh]) AND (‘Robotics’[MeSH]), (‘Ureteral Neoplasms’[MeSH]) AND (‘Robotics’[MeSH]) AND (‘Laparoscopy’[MeSH]).

The list of generated articles was screened by title and abstract by three authors independently (T.S., S-M.L, I. R.) and then relevant full papers were scrutinised. Review articles and bibliographies were also searched to find additional relevant papers. Data were extracted independently by two authors (T.S. and N.S.). A senior author independently (O.A.) cross checked findings to verify end results.

Articles were excluded if the procedure was not performed for a urothelial malignancy, if the patients were aged < 18 years, and if the study did not include both LNU and RNU techniques.

The outcomes of interest were; surgical technique, surgical outcomes [e.g. as estimated blood loss (EBL), operative time (OT), lymph node dissection (LND)], oncological outcome [e.g. positive surgical margins (PSM), positive lymph nodes, tumour recurrence, distant metastases], and perioperative outcomes (e.g. hospital length of stay, complications, mortality). Furthermore, we included studies comparing the differences in cost.

Where data were similar a cumulative comparison analysis was conducted to better represent the comparison between the two groups. Each study was assessed for quality in accordance with the Levels of Evidence published by Centre for Evidence-Based Medicine (CEBM), Oxford, UK [12].

Results

Literature search

The search strategy yielded 273 articles, with 259 excluded on the basis of title and/or abstract. The remaining 14 articles were screened, with four identified that met the inclusion criteria (Fig. 1) [9,13–15]. This

included two matched-comparison studies [9,13], one cohort study [14], and one population-based study [15]. In all, 1630 patients were included, of which 838 underwent LNU and 792 RANU. The patient characteristics for each study are given in Table 1 [9,13–15].

Of note, one study was excluded as it compared LNU and RANU in a paediatric population [16], and two studies were excluded as case series included LNU and RANU but the individual data for each were not extractable [17,18]. The remaining seven studies excluded did not compare or report on LNU and RANU, but reported case series of one procedure or the other, or review papers. No randomised controlled trials were identified.

Three studies compared between the two procedures with significant heterogeneity on reporting outcomes, and one study looked at cost comparison. Where possible a cumulative comparative analysis was done.

Surgical outcomes

Tables 2–4 summarise the findings of the review.

OT

All three studies found the mean OT to be less for LNU [9,13,14], with two reporting this to be statistically significant [13,14].

EBL

Ambani et al. [13] found LNU to have significantly less EBL. While the remaining two studies found a lesser EBL with RANU [9,14], with Hu et al. [9] finding this to be statistically significant.

PSM rate

There was no difference between the two groups for PSM rates. Ambani et al. [13] and Melquist et al. [14]

found LNU PSM rates of 5% and 6%, respectively; and RANU PSM rates of 9% and 0%, respectively. Neither found the difference to be statistically significant. Cumulative analysis found no difference between the two groups.

LND

The median node count was found to be higher in RANU in both studies that recorded this (5.5 vs 1.0 in Ambani et al. [13]; 21 vs 11 in Melquist et al. [14]). The positive node count was also higher in RANU (29% vs 17% in Ambani et al. [13]; 21% vs 5% in Melquist et al. [14]).

Postoperative complications

Postoperative outcomes were reported heterogeneously across the four studies.

Ambani et al. [13] and Melquist et al. [14] used the Clavien–Dindo classification system. These studies found minor complications (Clavien–Dindo grade \leq III) to be 18.2% and 19% in LNU, and 27.2% and 3% in RANU. For major complications, Ambani et al. [13] reported one Clavien–Dindo grade \geq IIIa in the LNU group (a fascial dehiscence of the hand port site). Melquist et al. [14] reported a major complication rate of 4.7% in LNU vs 7.0% in RANU ($P > 0.05$).

Hu et al. [9] did not report Clavien–Dindo complications, but found a faster return to oral intake after RANU compared with LNU (1.59 vs 2.17 days, $P = 0.043$), but there was an improved visual analogue scale (VAS) pain score in LNU (3.93 vs 6.22, $P = 0.043$).

Trudeau et al. [15], in the largest reported series, reported a significantly lower overall complication rate in RANU (11.9% vs 18.2%, $P < 0.001$).

Overall complication rates were statistically lower in the RANU group (12.5%) vs the LNU group (18.8%)

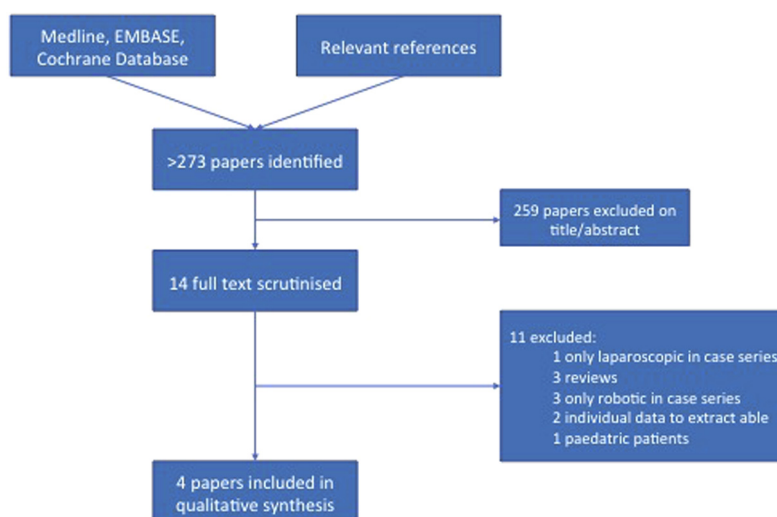


Fig. 1 PRISMA flowchart of search.

Table 1 Characteristics of studies included in the systematic review.

Reference	Country	Number of Institutions	Years data collected	RANU/ LNU	No. of patients	Age, years mean (SD) or mean (range)	% Male	Follow-up, months, median (range)	Co-morbidities
Ambani et al. [13]	USA	Single	2009–2011	LNU	22	70.8 (2.2)	72.7	15	Mean (SD) CCI 2.8 (0.5)
				RANU	22	70.1 (2.2)	63.6	10	Mean (SD) CCI 2.1 (2.1) <i>P</i> = 0.24
Hu et al. [9]	Taiwan	Single	2011–2013	LNU	18	69.6 (5.7)	27.7	47.8 (11.9–156.5)	ASA-PS 1 = 0, ASA-PS 2 = 3 (16.7%), ASA-PS 3 = 10 (55.6%), ASA-PS 4 = 2 (11.1%). Hydronephrosis 11 (61.1%), previous abdominal surgery 4 (22.2%), ESRD 2 (11.1%), CKD 16 (88.9%), simultaneous bladder UC 4 (22.2%)
				RANU	18	70.4 (6.3)	27.7	6.1 (0.6–30.3)	<i>P</i> > 0.05 for all. ASA-PS 1 = 0, ASA-PS 2 = 8 (44.4%), ASA-PS 3 = 6 (33.3%), ASA-PS 4 = 0. Hydronephrosis 12 (66.7%), previous abdominal surgery 5 (27.8%), ESRD 3 (16.7%), CKD 15 (83.3%), simultaneous bladder UC 4 (22.2%)
Melquist et al. [14]	USA	Single	2011–2014	LNU	63	72.6 (65.8–81.8)	57.1	30.9 (16.1–48.3)	-
				RANU	37	68.0 (63.6–73.6)	70.2	8.5 (1.8–15.3)	-
Trudeau et al. [15]	Canada	Multiple	2008–2010	LNU	735	70.6	59.9	-	CCI 0 = 58.1%, 1 = 31.7%, ≥ 2 = 10.2%
				RANU	715	70.7	63.0	-	CCI 0 = 60.7%, 1 = 31.0%, ≥ 2 = 83%
						<i>P</i> = 0.646 <i>P</i> = 0.06 <i>P</i> = 0.951	<i>P</i> = 0.215		<i>P</i> = 0.376

ASA-PS, American Society of Anesthesiologists Physical Status; CCI, Charlson Comorbidity Index (measure of comorbidity severity and risk of mortality); CKD, chronic kidney disease; ESRD, end-stage renal disease; UC, urothelial cancer.

Table 2 Operative details of studies included in the systematic review.

Reference	LNU/ RANU	Approach	Position	LNU approach for distal ureter	No. of ports	Tumours location, <i>n</i> (%)	Pathological status, <i>n</i> (%)	Chemo, <i>n</i> (%)	OT, min, mean (SD) or mean (range)	EBL, mL, mean (SD) or mean (range)	PSM, <i>n</i> (%)	Node count, median (IQR)	Positive nodes, <i>n</i> (%)
Ambani et al. [13]	LNU		Low lithotomy + partial flank position (60° to table)	Lap or hand- assisted. Bladder cuff excision endoscopic 14 patients, open 6 patients.	–	14 renal, 6 ureter: 3 proximal, 3 distal, 2 mixed	T0, 1 Tis, 1 Ta, 6 T1, 4 T2, 2 T3N0, 6 T3N2, 2	0 (0)	251 (14)	233 (27)	1 (5)	1.0	2 (29)
	RANU			N/a	–	14 renal, 6 ureter: 1 proximal, 5 distal, 2 mixed	T0, 1 Tis, 1 Ta, 6 T1, 4 T2, 2 T3N0, 6 T3N2, 2	3 (14) neoadjuvant	298 (12)	380 (42)	2 (9)	5.5	2 (17)
Hu et al. 2015 [9]	LNU	7-cm Gibson incision for hand port		Hand-assisted	–	10 renal 5 ureter 3 mixed	Ta, 7 (38.9) T1, 2 (11.1) T2, 2 (11.1) T3, 7 (38.9) N0, 16 (88.9)N1, 2 (11.1)	–	<i>P</i> = 0.03 250.17 (140–410)	<i>P</i> = 0.02 358.33 (50–2000)	<i>P</i> = 0.56 –	–	–
	RANU	Robot re- docked after nephrectomy. Patient not repositioned.	Lateral flank position (diseased side up)	N/a	5	10 renal 5 ureter 3 mixed	Ta, 3 (16.7)T1, 5 (27.8)T2, 6 (33.3) T3, 4 (22.2)N0, 17 (94.4)N1, 1 (5.56)	–	255.17 (110–540)	68.89 (10– 350)	–	–	–
Melquist et al. 2016 [14]	LNU	Transperitoneal for dissection kidney/ureter/ LN.		Extraperitoneal via Gibson excision	–	29 renal (46)23 ureter (37) 11 mixed (17)	T0 = 6Tis, 3 (5) Ta, 16 (25)T1, 10 (16)T2, 8 (13)T3/ 4, 20 (32)	34 (54) neoadjuvant	<i>P</i> = 0.333 234 (204– 288)	<i>P</i> < 0.001 200 (125– 375)	4 (6)	11 (5.5– 21)	13 (21)
	RANU	Robot over patient hip at 45°, facing contralateral shoulder.		N/a	5	21 renal (57)9 ureter (24)19 mixed (51)	T0, 5Tis, 2 (5)Ta, 9 (24)T1, 12 (32) T2, 2 (5)T3/4, 7 (19)	19 (51) neoadjuvant	306 (234– 354)	150 (100– 300)	0 (0)	21 (16– 30)	2 (5)
						<i>P</i> > 0.05	<i>P</i> > 0.05	<i>P</i> > 0.05	<i>P</i> < 0.001	<i>P</i> = 0.13	<i>P</i> = 0.29		

Chemo, chemotherapy; IQR, interquartile range.

Table 3 Postoperative outcomes of studies included in the systematic review.

Study	LNU/ RANU	Hospital stay, days	Other information	Complications, <i>n</i> (%)	Transfusion rate, <i>n</i> (%)	Follow- up, months	Mortality, <i>n</i> (%)	Intravesical recurrence, <i>n/N</i> (%)	Local recurrence, <i>n</i> (%)	Distant metastasis, <i>n</i> (%)	Disease free at follow- up, <i>n</i> (%)
Ambani et al. 2014 [13]	LNU	3.1	–	1 intraoperative (not stated) Clavien I, 2 Clavien II, 2 Clavien IIIb, 1 (fascial dehiscence of hand port site requiring surgical intervention)	0 (0)	15	Overall, 2 (9.1) Cancer specific, 2 (9.1)	7/19 (37), 2 had previously had cystectomy		5 (23)	16 (73)
	RANU	3.1	–	1 intraoperative (haemorrhage requiring transfusion) Clavien I, 4 Clavien II, 2 Clavien IIIb, 0 Clavien V, 1 postop. death due to haematemesis after discharge	2 (9.1)	10	Overall, 4 (18) Cancer specific, 2 (9.1)	8/24 (36)		7 (32)	11 (52)
Hu et al. 2015 [9]	LNU	9.61 (3–6)	<i>P</i> = 0.93 Ileus 0/resumption oral intake 2.17 (1–3) days/VAS pain score 3.93 (3–6)	–	–	47.8 (11.9– 156.5)	Overall, 5 (27.8) Cancer specific, 3 (16.7)	6 (33.3)	Renal fossa 2 (11.1)	<i>P</i> = 0.41 2 (11.1)	<i>P</i> = 0.08 –
	RANU	6.22 (3– 10)	Ileus 0/resumption oral intake 1.59 (0.5–3) days/ VAS pain score 6.22 (3–10)	–	–	6.1 (0.6– 30.3)	Overall, 2 (11.1) Cancer specific, 1 (5.6)	2 (11.1)	0 (0)	4 (22.2)	–
		<i>P</i> = 0.043	<i>P</i> > 0.05/ <i>P</i> = 0.043/ <i>P</i> = 0.043				<i>P</i> = 0.781/ <i>P</i> = 0.729	<i>P</i> = 0.849		<i>P</i> = 0.093	
Melquist et al. 2016 [14]	LNU	3 (2.5–4)	–	Clavien II, 12 (19) Clavien IIIa, 1 (2) Clavien IIIb, 1 (2) Clavien IVa, 1 (2)	19 (30)	30.9 (16.1– 48.3)	–	25 (40)			DSS (94) at 1 year
	RANU	5 (4.6– 6.3)	–	Clavien II, 1 (3) Clavien IIIa, 0 (0) Clavien IIIb, 2 (5) Clavien IVa, 2 (5). <i>P</i> > 0.05	3 (8)	8.5 (1.8– 15.3)	–	9 (24)			DSS (94) at 1 year
Trudeau et al. 2014 [15]	LNU	5.83		Overall complications (18.2)	<i>P</i> = 0.012 104 (14.1)		In-hospital mortality (1.4)				
	RANU	5.7		Overall complications (11.9)	93 (13.0)		In-hospital mortality (0)				
		<i>P</i> > 0.05		<i>P</i> < 0.001	<i>P</i> > 0.05		<i>P</i> = 0.002				

DSS, disease-specific survival; Clavien, Clavien-Dindo classification of complications.

Table 4 Cumulative comparison analysis.

Outcome	RANU, n/N	LNU, n/N	P
Overall complications	97/774	154/820	< 0.001
<i>Clavien–Dindo complications</i>			
I	4/59	2/85	0.21
II	3/59	14/85	0.05
III	2/59	3/85	0.96
IV	2/59	1/85	0.38
V	1/59	0/85	0.20
PSM	1/59	6/85	0.18
Follow-up median range across studies, months	6–30	12–48	
Bladder recurrence	19/77	38/103	0.09
Distant metastasis	11/40	7/40	0.29
Disease-specific mortality	3/40	5/40	0.46
Overall survival	69/77	92/103	0.95
Postoperative mortality (in-hospital death)	1/737	10/757	0.03

($P < 0.001$). However, subclassifying complications to Clavien–Dindo classification yielded no difference between the two groups.

Mortality

Trudeau et al. [15] reported a significant increase in in-hospital mortality in the LNU group (1.4% vs 0.0%, $P = 0.002$). While Ambani et al. [13] had one postoperative death in the RANU group. A cumulative analysis found postoperative death rates to be statistically less in the RANU group (Table 4) ($P = 0.03$).

Oncological outcomes

Hu et al. [9] reported better overall and cancer-specific survival in LNU; however this was not statistically significant (overall 27.8% vs 11.1%, $P = 0.781$; cancer-specific 16.7% vs 5.6%, $P = 0.729$). Melquist et al. [14] found no difference in disease-specific survival at 1 year (94% vs 94%). Ambani et al. [13] found overall mortality was higher in the RANU group (18% vs 9.1%), but cancer-specific mortality was the same across the groups (9.1% vs 9.1%).

There was no statistically significant difference between the groups for bladder recurrences ($P = 0.09$), at 24.7% in the RANU group vs 36.9% in the LNU group, despite the slight increase in the LNU group [9,13,14].

Local recurrence was only reported in one study, which found no cases in the RANU group but two (11.1%) in LNU group, both recurrences were found in the renal fossa [14].

There was a trend towards a higher rate of distant metastases in the RANU groups (27.5%) vs the LNU groups (17.5%); however, this was not statistically significant ($P = 0.29$) [9,13].

Ambani et al. [13] reported on disease-free survival and found a trend favouring LNU over RANU at a

median follow-up of 15 months and 10 months, respectively (73% vs 52%, $P = 0.08$).

Cost

Trudeau et al. [15] reported on comparative costs, in their USA-based study. They found the mean cost to be significantly higher in RANU (\$23 235 vs \$17 637, $P < 0.001$).

Quality assessment of studies

The general quality of the studies was poor, with no randomised trials included. The three comparative trials and the population-based study were all retrospective in nature. This included two level 2b studies [14,15], and two level 3b studies [9,13], according to the CEBM levels of evidence [12].

Discussion

Overall summary

Although the RANU is emerging, this is the first systematic review to evaluate the outcomes of comparative studies between LNU and RANU. Minimally invasive NU has become increasingly popular, with reported improved perioperative outcomes and comparable oncological results to open NU [10]. However, there remains a paucity of good data available in the literature. There is currently no randomised controlled trial Level 1 evidence, and as found in the present review a paucity of data comparing LNU and RANU. With this in mind, the present evidence suggests that these two techniques are currently equivocal in terms of perioperative and oncological performance for this technique; however, there seems to be lower overall complication rates, as well as postoperative mortality in the RANU group.

Operative outcomes

All the studies reporting on OTs found them to be higher in RANU cases [9,13,14]. However, the data reported by Ambani et al. [13] represent their initial experience with the robot for this procedure, while Melquist et al. [14] performed more complete LNDs in their RANU cases. Furthermore, Ambani et al. [13] and Hu et al. [9] 're-docked' the robot during their procedure, which Melquist et al. [14], in the more recent paper, showed to be avoidable step. Indeed, in published RANU case series in which the patient or robot are not repositioned the mean OT is consistently <200 min [19–21], while in those studies that re-docked the mean OTs were in concordance with those seen here at ~300 min [22,23].

EBL was reduced in RANU in two papers [9,14], with Hu et al. [9] finding this to be significant (358.33 vs 68.89 mL, $P < 0.001$). Ambani et al. [13] found a trend towards higher EBL and transfusion rates in RANU patients, but again this was attributed to a learning-curve effect, and their results do not reflect other published RANU series, such as Hemal et al. [20] and Lee et al. [21], who reported an EBL of 103 and 99 mL, respectively. Melquist et al. [14] reported a significantly lower transfusion rates in RANU (8% vs 30%, $P = 0.012$) and this trend was supported in the largest study in the literature (13.0% vs 14.1%, $p > 0.05$) [15].

LND should be performed in all patients with $\geq T2$ tumours, with radiologically or operative lymph node enlargements, it provides key diagnostic information and may be curative in patients with either known limited nodal spread or unseen metastases [24]. Melquist et al. [14] performed a retrospective cohort study with the primary outcome to assess LND in LNU and RANU. That paper, and Hu et al. [9], found RANU to yield a higher median lymph node count. In both cases LNU had a higher positive node count.

Taken together, these findings suggest that with experience and the adoption of RANU without repositioning or re-docking, that RANU could become a more efficient technique in terms of OT and EBL, and a more effective procedure in terms of ability to yield lymph nodes as required.

Complications and mortality

Overall complications were higher in LNU in all but one study [13]. Trudeau et al. [15] found no significant difference in postoperative length of stay; however, overall complications were reduced from 18.2% to 11.9% in RANU procedures ($P < 0.001$). No other series reported a significant difference in complication rates. This was reflective in the cumulative analysis, whereby the RANU group had less complications overall, but is heavily weighed by the large Trudeau et al. [15] study.

Mortality rates were reportedly inconsistently across the studies. In the largest series, there is a significantly increased in-hospital mortality in LNU (1.4% vs 0%, $P = 0.002$) [15]. The other two studies that reported on mortality found no significant difference in both overall and cancer-specific mortality [9,13].

Oncological outcomes

Bladder recurrence rates ranged from 33 to 40% in LNU, which was in agreement with the range of 19–43% reported in a meta-analysis by Ribal et al. [25]. Recurrence rates in RANU cases reported here ranged from 11% to 36%. Lim et al. [26], in a cumulative analysis of RANU series, reported a recurrence rate of 0–44.4%. Although no statistically significant difference was found, there is a suggestion of a trend towards improved recurrence rates with RANU. The 'gold standard' for bladder cuff excision is extravesical or transvesical excision of the distal ureter; Lim et al. [26] hypothesised that the technical challenge this poses laparoscopically, in comparison to more advanced dexterity offered by robotics may explain the trend towards improved recurrence rates.

Local recurrences are considered rare after NU, with rates of 4–15% in LNU, and 2.4% in a pooled analysis of RANU [26]. Only one study in the present series reported on local recurrence, finding a rate of 0% in RANU compared with 11.1% in LNU [14]. These should be interpreted with caution given the small sample size, but suggest that local recurrence rates are at least comparable between the two techniques.

Both studies reporting distant metastases found a trend towards improved rates in LNU, although neither found significance [9,13]. In RANU, Ambani et al. [13] reported a recurrence rate of 32% and Hu et al. [9] reported a recurrence rate of 22%. In a meta-analysis by Rai et al. [10] the pooled rate of distant metastasis for LNU across 16 studies was found to be 11.0%, and 14.7% in open NU.

Cost

Concern over cost in robotics is often raised. Trudeau et al. [15] reported RANU to be a more costly procedure (\$17 637 vs \$23 235, $P < 0.001$). However, the generalisability of this to other populations is questionable. Furthermore as robotics continues to increase in popularity and availability of equipment these costs are likely to decrease.

Limitations

Firm conclusions from the available literature are limited in three of the studies by small cohort sizes [9,13,14]. In the Trudeau et al. [15] study, although

large, it is a population-based study and so should be interpreted with caution. Secondly, the quality of evidence is low, with all available data from retrospective studies with no randomisation, which has an inherent risk of bias. Thirdly, all the studies reviewed use different techniques in both LNU and RANU cases, this again makes them hard to interpret and compare fairly. With all results reported differently between the studies. Finally, there is a limited follow-up period, in particular in RANU with the longest follow-up being only 10 months [13], this makes meaningful interpretation of oncological and survival outcomes difficult.

Implications for practice and research

The available literature suggests outcomes from RANU are at least comparable to LNU; however, firmer conclusions cannot be made given the limitations discussed. Results from other case series suggest that with increased experience RANU may provide favourable performance in terms of OT, EBL, complications, and mortality [19–21]. Furthermore, both Hu et al. [9] and Melquist et al. [14] report increased lymph node yield, which is an added benefit of RANU indicating that this is an option and is comparable with open surgery.

The present review supports the continued use of both techniques with equipoise. Further research should look to address the limitations discussed – preferably in the form of a large randomised controlled trial. Given the rarity of upper urothelial tumours this may be hard to achieve in a single institution and may need a multi-institutional, multi-national study.

Conclusions

Despite the paucity of current comparative evidence on RANU and LNU, the present systematic review suggests they are equivalent in terms of perioperative and oncological performance. Furthermore, there may be a lower overall complication rate, as well as postoperative mortality in the RANU group. We await further comparative data to add to this field, preferably in the form of a randomised controlled trial, which would be appropriate.

Conflicts of interest

None.

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