

evidence | *note*

In response to an enquiry from the West of Scotland
Cancer Network

Number 75 January 2018

What is the clinical and cost-effectiveness evidence comparing robot assisted laparoscopic partial nephrectomy with open partial nephrectomy or conventional laparoscopic partial nephrectomy in patients with T1a or T1b renal cancer?

What is an evidence note?

Evidence notes are rapid reviews of published secondary clinical and cost-effectiveness evidence on health technologies under consideration by decision makers within NHSScotland. They are intended to provide information quickly to support time-sensitive decisions. Information is available to the topic referrer within a 6-month period and the process of peer review and final publication of the associated advice is usually complete within 6–12 months. Evidence notes are not comprehensive systematic reviews. They are based on the best evidence that Healthcare Improvement Scotland could identify and retrieve within the time available. The reports are subject to peer review. Evidence notes do not make recommendations for NHSScotland, however the Scottish Health Technologies Group (SHTG) produces an Advice Statement to accompany all evidence reviews.

Key points

- No randomised controlled trials (RCTs) were identified comparing robot assisted laparoscopic partial nephrectomy (RALPN) with open partial nephrectomy (OPN) or with conventional laparoscopic partial nephrectomy (LPN).
- The evidence base consists of meta-analyses of short-term observational studies, many of which are retrospective and at high risk of bias. In these studies:

RALPN is associated with fewer postoperative complications, less blood loss and shorter length of hospital stay than OPN, with no statistically significant differences between study groups in rate of positive surgical margins or degree of decline in estimated glomerular filtration rate (eGFR).

RALPN is associated with shorter warm ischaemia time, reduced eGFR decline and a lower rate of conversion to open surgery or radical nephrectomy than LPN. There was no statistically significant difference between study groups in positive surgical margin rate or post-operative complications. RALPN is associated with shorter length of hospital stay than LPN.

- One US cost-effectiveness analysis reported an incremental (2014) cost per avoided peri-operative complication of \$5,005 (£3,877) when comparing RALPN with OPN.
- In a retrospective analysis of routinely collected NHS data RALPN was associated with reduced 90-day complication costs and total medical costs at one year when compared with OPN. Differences between LPN and RALPN were not statistically significant.
- Evidence was insufficient to characterise the learning curve associated with initial experience in RALPN or to determine minimum surgeon or hospital case volume.

Definitions

Estimated glomerular filtration rate (eGFR): a measure of kidney function defined as the volume of plasma which is filtered by the glomeruli per unit time. It is usually measured by estimating the rate of clearance of a substance from the plasma¹. In studies, post-operative eGFR is typically measured between one month and six months after surgery.

Partial nephrectomy (PN): the removal of part of the kidney. Partial nephrectomy is used to treat small accessible tumours which have not metastasised. This is sometimes called 'nephron sparing surgery' (NSS)².

Tumour, Nodes, Metastases (TNM) system: a way of classifying malignant tumours. In the context of renal cancer, early-stage cancer is defined as 'T1', which is where the tumour is completely inside the kidney. 'T1' cancers are further subdivided into 'T1a', where the tumour is ≤ 4 cm, and 'T1b', where the tumour is >4 and ≤ 7 cm².

Warm ischaemia time (WIT): duration of interruption of renal blood flow during partial nephrectomy. A WIT of ≤ 25 minutes is one component of measures of surgical quality³.

Literature search

A systematic search of the secondary literature was carried out between 7-8 June 2017 to identify systematic reviews, health technology assessments and other evidence based reports. Medline, Medline in process, Cochrane, Embase and Web of Science databases were also searched for systematic reviews and meta-analyses.

The primary literature was systematically searched on the 27 June 2017 using the following databases: Medline, Medline in process, Cochrane, Embase and Web of Science. Results were limited to randomised controlled trials and volume and outcome studies. An additional search to identify literature comparing the learning curve for robotic partial nephrectomy and laparoscopic partial nephrectomy was carried out on the 19 July 2017.

Key websites were searched for guidelines, policy documents, clinical summaries, economic studies and ongoing trials.

Concepts used in all searches included: Renal cancer/tumour/neoplasm, early stage, T1a/T1b, robot assisted laparoscopic partial nephrectomy (RALPN), laparoscopic partial nephrectomy (LPN), open partial nephrectomy (OPN). A full list of resources searched and terms used are available on request.

Introduction

Partial nephrectomy which preserves renal function is the gold standard surgical treatment for early kidney cancer (T1a or T1b). Partial nephrectomy (PN) procedures can be undertaken using either open or laparoscopic approaches. With open approaches (OPN) a part of the kidney is removed through a large incision. The procedure is carried out under direct vision. For laparoscopic PN (LPN) the surgeon inserts a laparoscope and other surgical instruments through small incisions in the abdominal wall, and uses them to remove part of the kidney. Robot assisted laparoscopic PN (RALPN), first reported in 2004⁴, is a variant on the laparoscopic approach².

Health technology description

The technology for RALPN comprises a surgeon console, computerised control system, and patient-side cart that houses the robotic arms which hold the dual telescope and surgical instruments. The surgeon operates the robotic arms by remote control from the console while viewing the magnified 3D surgical field on a monitor. The da Vinci® System (Intuitive Surgical Inc., California)⁵ is available with three or with four robotic arms. Products include the da Vinci® Xi, the da Vinci® Si and the da Vinci® Si-e. da Vinci® robotic systems are installed in three centres in Scotland; Edinburgh, Glasgow and Aberdeen and are presently used to provide a robot assisted laparoscopic prostatectomy service.

Epidemiology

Kidney cancer represents around 3% of all cancer diagnoses in Scotland and is more common in men than in women. In 2015 there were 1,013 new diagnoses. Recorded incidence has increased by around 25% in the last decade (see table 1)⁶. This is likely due, in part, to an increase in the use of cross-sectional abdominal imaging resulting in a greater number of incidental findings⁷. Renal cell carcinoma is the most common form of kidney cancer, accounting for 90% of all renal malignancies².

In 2014 there were 92 cases where the renal cancer was graded as T1a and nephron sparing surgery was considered appropriate⁸. The current standard of care in Scotland is OPN, with access to LPN in a few sites. There has been early experience of RALPN at Aberdeen Royal Infirmary and Queen Elizabeth University Hospital, Glasgow (Mr Grenville Oades, Consultant Urological Surgeon, Greater Glasgow and Clyde, Personal Communication, 3 May 2017).

Table 1: Epidemiology of kidney cancer in Scotland ^{6, 8}

	Males	Females	Total
Change in incidence 2005-2015	+28%	+20%	+25%
Number of new cases diagnosed in 2015	634	379	1013
Cases in 2014 where renal cancer was graded as T1a and nephron sparing surgery was appropriate	–	–	92
Number of deaths in 2015	214	147	361

In England, against a background of a 160% increase in the overall number of recorded partial nephrectomies, the number of RALPN procedures between 2009 and 2014 increased from 12 (3% of all PN procedures) to 291 (27% of all PN procedures)⁹. The proportion of procedures carried out by LPN has

stayed fairly stable across this time period at around 25%. The use of OPN has decreased from 73% to 46% of PN procedures.

Clinical effectiveness and safety

Evidence was examined on the clinical effectiveness and safety of RALPN compared with OPN or LPN in patients with early stage renal cancer. Key outcomes of interest included the trifecta of surgical success (negative surgical margins, no post-operative complications and warm ischaemia time ≤ 25 minutes) and outcomes reflecting the preservation of renal function (90% glomerular filtration rate (GFR) and no upgrading of severity of chronic kidney disease (CKD)). Additional peri-operative outcomes examined were blood loss, conversion to open surgery or radical nephrectomy, operating duration and use of critical care.

RALPN versus OPN

No randomised controlled trials were identified. The evidence base comparing RALPN with OPN consists of non-randomised observational studies. These include single centre and multi-centre comparisons. Many are retrospective and most focus on short-term peri-operative outcomes rather than longer term outcomes such as survival or cancer recurrence. Where such oncological outcomes were reported, variation in length of follow-up period prevented meta-analysis¹⁰. Potential confounding factors include surgeon experience and volume of procedures; tumour size, complexity and location; and patient factors such as baseline renal function and extent of previous surgery.

Three systematic reviews were identified¹⁰⁻¹². On the basis that it was both the most up to date review and also incorporated sensitivity analysis based on risk of selection bias in the included studies the 2017 meta-analysis by Xia et al was selected for this evidence note¹². Key findings are outlined in table 2. The rate of overall post-operative complications (minor and major) was less in the RALPN group as was the extent of blood loss and length of hospital stay. There was no statistically significant difference between study groups in the rate of positive surgical margins or eGFR decline. Warm ischaemia time favoured OPN (studies in which cold ischaemia and/or off-clamp techniques were excluded) as did operative time. The benefits for these outcomes became not statistically significant when studies assessed as at risk of selection bias related to tumour complexity were excluded from the analysis.

Table 2: Findings of 2017 meta-analysis of comparative studies of RALPN and OPN¹²

Outcome	Number of studies (n patients)	Finding Risk ratio (RR) Weighted mean difference (WMD) Standardised mean difference (SMD)	P value	I2
Positive surgical margin rate	15 (2,924)	RR 0.87 (95% CI 0.54 to 1.34)	p=0.52	0%
Overall postoperative complications	13 (2,656)	RR 0.60 (95% CI 0.46 to 0.78)	p=0.0002	26%
Intra-operative complications	9 (1,489)	RR 0.61 (95% CI 0.29 to 1.27)	p=0.19	0%
Warm ischaemia time (mins)	8 (1,386)	WMD 3.65 (95% CI 0.75 to 6.56)	p=0.01	93%
Operative time (mins)	16 (3299)	WMD 18.56 (95% CI 2.13 to 35.00)	p=0.03	95%
eGFR decline (%)	3 (376)	WMD 0.99 (95% CI -0.52 to 2.50)	p=0.20	0%

eGFR decline (absolute ml/min)	5 (1,524)	WMD -1.56 (95% CI -3.41 to 0.28)	p=0.10	49%
Estimated blood loss	16 (2,833)	WMD -98.82 (95% CI -125.64 to -72.01)	p<0.00001	73%
Length of stay (days)	16 (3,183)	WMD -2.64 (95% CI -3.27 to -2.00)	p<0.00001	95%

RALPN versus LPN

No randomised controlled trials were identified. The evidence base comparing RALPN with LPN consists of non-randomised observational studies. These include single centre and multi-centre comparisons. Most are retrospective and focus largely on peri-operative outcomes rather than longer term outcomes such as survival or cancer recurrence. Potential confounding factors include surgeon experience and volume of procedures, tumour size, complexity and location as well as patient factors such as baseline renal function and extent of previous surgery.

Six systematic reviews were identified which conducted meta-analyses of between six and 26 studies based on literature searches conducted in 2012 to 2015^{4, 13-17}. Based on the methodological quality of the reviews, particularly around literature search rigour and assessment of quality of the included studies, and the range of outcomes examined, the 2015 systematic review with meta-analysis by Choi et al⁴ was selected for this Evidence Note. The review included 23 studies (three prospective, 20 retrospective) which focused on patients with kidney cancer (as opposed to renal masses more generally) and compared both surgical and patient outcomes. Studies on hand-assisted laparoscopic procedures were not specifically excluded from the analysis. Based on information provided by another analysis the proportion of tumours which were malignant was in the region of 80%¹⁷. In all but one of the studies mean tumor size was <4cm. The quality of the evidence as assessed by the methodological index for non-randomised studies (MINORS) was low. No study scored ≥ 15 out of a total possible quality score of 24. Sensitivity analysis according to study quality was not conducted. This, along with the substantial heterogeneity identified for several outcomes, indicates that caution is required when considering the meta-analysis findings which are outlined in Table 3.

There was no statistically significant difference between study groups in the positive surgical margin rate, complication rate, operative time, or estimated blood loss. Findings favoured RALPN for reduced warm ischaemia time and post-operative change in eGFR. Although these outcomes are related to long-term renal function, the clinical significance of the magnitude of the differences identified is unclear as no standard measure of minimally important difference is specified for these outcomes. The reduced warm ischaemia time was interpreted by the authors as relating to faster suturing technique with the robotic system. The finding for eGFR was based on only 3 studies, the largest of which focused on complex tumours. There was a lower rate of both conversion to open surgery and conversion to radical nephrectomy in the RALPN arm. Patients undergoing RALPN had shorter length of stay.

Table 3: Findings of 2015 meta-analysis of comparative studies of RALPN and LPN⁴

Outcome	Number of studies (n patients)	Finding Risk ratio (RR) Weighted mean difference (WMD) Standardised mean difference (SMD)	P value	I ²
Positive surgical margin rate	11 (1,680)	RR 1.09 (95% CI 0.64 to 1.84)	p=0.75	0%
Complication rate (Clavien-Dindo classification grades 1–2)	7 (1,238)	RR 1.06 (95% CI 0.85 to 1.31)	p=0.62	0%
Complication rate (Clavien-Dindo classification grades 3–5)	6 (1,152)	RR 0.94 (95% CI 0.61 to 1.46).	p=0.78	0%
Operative time (mins)	21 (1,844)	WMD 8.77 (95% CI -9.56 to 27.1)	p=0.35	91%
Estimated blood loss (ml)	19 (1,866)	WMD 5.72 (95% CI -31.43 to 42.87)	p=0.76	52%
Warm ischaemia time (mins)	14 (1,542)	WMD -2.97 (95% CI -5.05 to -0.89)	p=0.005	62%
eGFR decline (%)	3 (617)	SMD -0.18 (95% CI -0.34 to -0.02)	p=0.03	0%
Conversion to open surgery	7 (913)	RR 0.45 (95% CI 0.23 to 0.88)	p=0.02	0%
Conversion to radical nephrectomy	4 (508)	RR 0.19 (95% CI 0.07 to 0.50)	p=0.0006	46%
Length of stay (days)*	19 (1,779)	WMD -0.23 (95% CI -0.46 to -0.01)	p=0.04	45%
* This outcome also reported in text of published study as -0.21 (95% CI -0.36 to -0.07), p=0.004				

Ongoing trials

Two registered randomised controlled trials were identified as below:

[NCT02933398](#): A Prospective Randomized Controlled Trial Comparing Two Minimally Invasive Surgical Modalities - Robotic Assisted Vs. Pure Laparoscopic Partial Nephrectomy For Small Renal Masses. Completion date recorded as June 2017.

[NCT02924922](#): Robot Assisted Partial Nephrectomy (RAPN) in Selective Ischemia Versus Laparoscopic Partial Nephrectomy (LPN) in Total Ischemia: Prospective Randomized Study to Assess Oncological and Functional Outcomes. Completion date recorded as February 2018.

Device safety

A study of adverse events associated with da Vinci robotic surgery reported in the USA between 2000 and 2013 identified 1,565 events associated with urological surgery (most commonly prostatectomy)¹⁸. There were 30 deaths, 272 injuries and 902 instances of device malfunction. Device malfunctions encompassed system errors, video and imaging problems, broken instruments falling into the patient's body, electrical arcing, sparking or charring of instruments, and uncontrolled movements or spontaneous powering on/off of system.

No incidents attributable to robot assisted surgery have been recorded by the NHSScotland Incident Reporting & Investigation Centre (IRIC) database (C Campbell, IRIC. Personal Communication, 30 August 2017). One incident relating to the dismantling of the robotic system was recorded by NHS Greater Glasgow and Clyde risk management systems (C Campbell, IRIC. Personal Communication, 20 September 2017).

The NHS England National Reporting and Learning System (NRLS) recorded 104 incidents relating to the robotic device/equipment since 2007. Of these, 95 were categorised as no harm, 8 as low harm and 1 as moderate harm (P Salter, NRLS Oversight and Business Support Officer, Personal Communication, 10 October, 2017).

Learning curve

The learning curve for any procedure may be conceptualised as the number of procedures required to reach a defined measure of adequacy or competency. Comparisons of the learning curve for surgical procedures requires attention to potential confounding factors including skill, previous experience, and training of the surgeon(s) and surgical assistant(s)/team, extent of supervision, and patient factors such as tumour complexity and comorbidities. Studies relating to RALPN learning curve varied widely in the number of cases examined and in the measure of adequacy of outcome(s). Studies did not specify a pre-defined competency level but instead sought to identify plateaus for selected outcomes over time.

Only one study directly compared the initial learning curve for RALPN with that for LPN19. The outcomes for the first 116 consecutive procedures conducted by each of two surgeons at a single institution were retrospectively examined in four cohorts of 29 cases. The surgeon conducting LPNs had completed a minimally invasive fellowship. The surgeon conducting the RALPNs had no LPN experience but did have prior robotic prostatectomy experience. In both the third and fourth cohort of patients there was a statistically significant difference in log warm ischaemia time favouring RALPN, leading the authors to conclude that the RALPN learning curve was shorter than that for LPN. There was no statistically significant difference between patient groups in overall complication rates which did not decrease between cohorts for either technique. Operative times, which included robot docking time gradually declined in the RALPN cohorts but for the LPN group operative time varied and there was no clear pattern.

Four studies examined the learning curve for RALPN for experienced laparoscopic surgeons converting to using the robotic procedure^{20,21,22,23}. All were retrospective single-surgeon analyses and there was wide variation in definitions of competency and level of previous robotic experience, for example with robotic prostatectomy. Learning curve ranged from no additional procedures to an estimated 75 procedures. Two studies small studies examined the learning curve for RALPN for experienced robotic surgeons. The learning curve was identified as 20²⁴ or 30²⁵ cases depending on the peri-operative outcome(s) examined.

Volume outcome

Two studies were identified. The US context and the specific volume cut-offs used may limit applicability to NHSScotland.

One study examined the impact of hospital volume on postoperative complications following RALPN. Analysis was based on the United States (US) National Inpatient Sample (NIS)²⁶ which is a stratified 20% sample of discharges from US community hospitals. A retrospective cohort of 17,583 cases from 323 hospitals between 2009 and 2011 was selected. Adjustment for case mix was limited to those potential

confounding factors which were recorded in the administrative database such as age, gender and diagnosis of kidney cancer. Pathology details such as tumour size and complexity are not recorded in the NIS and complications were identified using ICD-9 codes which are not specific to urology and do not indicate severity of complications. Study findings are outlined in Table 4 and these suggest there was regionalisation of care to highest volume hospitals. At the cut-offs used in this analysis, high volume hospitals had a 42% lower odds of complications when compared with low volume hospitals. This was statistically significant (OR 0.58, 95%CI 0.37 to 0.90, $p=0.016$).

Table 4: Association between hospital volume and postoperative complications following RALPN

	High Volume	Medium volume	Low volume
Number of hospitals	99	112	112
Number of procedures	13,645	2,975	964
Procedure volume cut-offs			
2009	≥35	14-34	4-13
2010	≥39	14-38	4-14
2011	≥41	14-40	5-13
Any complication (%)	10	12	15
Peri-operative transfusion rate (%)	6	8	9
Odds ratio (OR) for development of postoperative complication compared with low volume hospital after adjusting for patient and hospital characteristics	0.58 (95% CI 0.37 to 0.90) $p=0.016$	0.73 (95% CI 0.46 to 1.16) $P=0.178$	N/A

One US study compared peri-operative outcomes by annual surgeon volume²⁷. Analysis was based on the Premier Hospital Database which collates a nationally representative sample of inpatient billing data. Annual volume per surgeon was divided into quintiles based on number of cases: very low (≤ 2), low (3-4), intermediate (5-7), high (8-13) and very high (≥ 14). The authors noted that the definitions of high and very high volumes were not applicable to large tertiary referral centres. Data for 39,773 patients from January 2003 to December 2015 were included, with findings adjusted for patient characteristics such as age, race and Charlson comorbidity index and hospital characteristics including hospital size, teaching status and location. Outcomes are in Table 5. Compared with very low volume surgeons, there was a statistically significant reduction in major complication rates associated with high and very high volume surgeons. Operating time was longer for very low volume surgeons compared to all other groups and there was benefit in length of hospital stay when intermediate, high and very high volume surgeons were compared with very low volume surgeons. There was no association between surgeon volume and blood transfusion rates.

Table 5: Adjusted outcomes for patients undergoing RALPN by surgeon volume²⁷

Surgeon annual case volume	Very low (≤2)	Low (3-4)	Intermediate (5-7)	High (8-13)	Very high (≥14)
Number of cases	10,611	7,162	7,199	6,875	7,926
Any complication rate (%)	29.0 (95% CI 25.2 to 32.9)	25.3 (95% CI 21.4 to 29.2)	24.4 (95% CI 20.7 to 28.1)	22.9 (95% CI 18.5 to 27.3)	23.3* (95% CI 19.8 to 26.8)
Major complication rate (%)	3.9 (95% CI 3.0 to 4.8)	4.4 (95% CI 3.1 to 5.6)	2.8 (95% CI 1.7 to 3.9)	2.4* (95% CI 1.5 to 3.3)	2.3* (95% CI 1.5 to 3.1)
Operating room time (min)	316 (95% CI 277 to 355)	272* (95% CI 244 to 300)	264* (95% CI 240 to 289)	255* (95% CI 227 to 282)	248* (95% CI 227 to 282)
Blood transfusion rate (%)	15.5 (95% CI 11.5 to 19.4)	18.3 (95% CI 10.5 to 26.2)	14.8 (95% CI 7.2 to 22.4)	17.5 (95% CI 8.5 to 26.5)	19.2 (95% CI 1.9 to 36.4)
% of patients experiencing prolonged length of stay	33.9 (95% CI 29.2 to 38.6)	30.8 (95% CI 25.3 to 36.3)	25.9* (95% CI 20.9 to 30.9)	21.2* (95% CI 16.6 to 25.9)	19.2* (95% CI 15.2 to 23.3)
*Statistically significant difference between this finding and the very low volume surgeon group					

Cost effectiveness

A US cost-effectiveness study, from a hospital administration perspective, compared in-hospital costs and health consequences (expressed as peri-operative complications and hospital deaths) of RALPN and LPN versus OPN. The time horizon used in the analysis was limited to the peri-operative period.

Transition probabilities for the decision tree model are based on the adjusted OR for peri-operative complications and deaths of RALPN/LPN vs OPN which were derived from a nationwide sample of 38,064 partial nephrectomies using open and minimally invasive procedures.

Itemised costs are based on data from a single US institution which conducted a high volume of robotic and open procedures and include: operating room and supply; room and board; anesthesia; pharmacy; laboratory and pathology; professional fees; blood bank. The cost data does not differentiate between patients with and without complications, hence the same basic cost is applied for each procedure regardless of occurrence of complications. All costs were expressed in USD at 2014 prices. The equivalent in GBP are reported here.

Mean in-hospital costs were \$13,186 (£10,214) for RALPN, \$10,782 (£8,355) for LPN, and \$12,539 (£9,713) for OPN. The higher operating room costs of RALPN were partially offset by lower postoperative costs including length of stay. Overall, the probability of experiencing a peri-operative complication including death was 23.17% for RALPN, 27.89% for LPN, and 36.08% for OPN. Hence the ICER (expressed as the incremental cost per avoided peri-operative complication) is \$5,005 (£3,877) per avoided peri-operative complication for RALPN vs OPN, while LPN dominated OPN as it results in lower overall costs

and fewer peri-operative complications. The ICER of RALPN vs LPN is not reported in the study but based on the above results, the implied ICER is \$50,932 (£39,467) per avoided peri-operative complication. A summary of the results is presented in Table 6.

Table 6: Incremental cost-effectiveness ratio for RALPN and LPN versus OPN in the base case

	RALPN	LPN	OPN
Cost	\$13,186 (£10,214)	\$10,782 (£8,355)	\$12,539 (£9,713)
Peri-operative complications or deaths	23.17%	27.89%	36.08%
Incremental cost per avoided event vs OPN	\$5,005 (£3,877)	Dominant	-

The results of the study suggest that LPN is cost effective compared to OPN. Compared to LPN/OPN, RALPN is associated with higher costs yet leads to fewer perioperative complications. However, it is not possible to draw firm conclusions regarding the relative cost-effectiveness of RALPN vs LPN/OPN because:

- Health consequences were expressed as clinical outcomes (perioperative complications), while oncological outcomes were not modelled, nor were overall survival and other health-related quality of life outcomes.
- Following on from the above, the short time horizon for the model does not capture potential differences in longer term outcomes and costs.
- Data from the US are unlikely to be applicable to the Scottish setting. Not only are the specific cost data unlikely to be generalisable, outcome data were drawn from a large-volume US institution (325 PN interventions undertaken from January 2009 to December 2010) which may not apply to low-volume hospitals and less experienced surgeons.

The costs reported in the US study can be benchmarked against the results of a retrospective cost comparison study with a one year follow-up undertaken in the UK setting⁹. The study used hospital episodes statistics data from NHS England to quantify and compare the 90-day complication rates and 1-year hospital activity and costs following different surgical modalities for PN. Data from October 2008 to September 2014 were analysed. The follow up period was one year. Healthcare activity included cancer related admissions, accident and emergency visits and outpatient appointments. Costs were estimated using Health Resource Group (HRG) tariffs inflated to 2015 values. It is worth noting that initial investment costs and maintenance costs of robot assisted surgery were excluded.

Findings are presented in Table 7. When compared with RALPN, procedure costs of OPN were significantly higher ($p < 0.001$). Procedure costs of LPN were significantly lower than RALPN ($p = 0.001$). When adjusted for age, deprivation and recorded pre-existing co-morbidities such as diabetes, liver disease and obesity, total medical costs post procedure at one year were lower in RALPN group when compared with OPN (£489, $p = 0.024$). A similar pattern was identified for 90-day complication costs which, when adjusted, were significantly lower in the RALPN cohort of patients (£230, $p = 0.002$). Differences in total medical costs and 90-day complication costs between LPN and RALPN were not statistically significant.

Table 7: Mean healthcare costs per patient up to one year after partial nephrectomy⁹

	RALPN n=610	LPN n=1,060	OPN n=2,605
Procedure cost (SD)	£4,444.34 (± £808.43)	£4,356.19 (± £833.60)	£5,024.19 (± £1451.16)
90-day complication costs [adjusted difference from RALPN]	£129.29	£200.49 [£104.26, p=0.082]	£317.21 [£230.17, p=0.002]
Total medical costs at 1-yr post procedure [adjusted difference from RALPN]	£2,089.37	£2,225.05 [£6.95, p=0.973]	£2,996.55 [£489.13, p=0.024]

Overall, including the costs associated with 90-day complication rates and 1-year hospital activity, RALPN seems to be less costly than OPN in the UK setting when adjusting for patient characteristics. No statistically significant difference in costs was reported for RALPN vs LPN.

Conclusion

The evidence base for the clinical effectiveness of RALPN is limited to short-term observational studies. These are at risk of bias, particularly around patient selection, and do not provide comparisons on outcomes such as cancer recurrence or survival. This low quality evidence suggests that compared with OPN, RALPN is associated with fewer postoperative complications, less blood loss and shorter length of hospital stay without impact on surgical margin rate or magnitude of eGFR decline. Compared with LPN, RALPN is associated with improvements in warm ischaemia time, eGFR decline, rate of conversion to other surgery and shorter length of stay.

It is difficult to draw firm conclusions regarding the relative cost-effectiveness of RALPN versus LPN/OPN due to the lack of evidence on their relative impact on quality of life and the short follow-up of the available evidence. Within a US setting, RALPN appears to be a cost-effective means of avoiding in-hospital complications for a willingness-to-pay higher than £3,877 per avoided complication. However, given the results are based on US data, there may be some uncertainty as to whether RALPN is cost effective versus OPN in a UK setting and when considering the impact on overall survival and quality of life. These results might not apply to low-volume hospitals or to other healthcare systems. An additional cost study from the UK reported that RALPN is cost saving at one year of follow up when compared to OPN, but not statistically different when compared to LPN. These two findings do not take into account the robot acquisition and maintenance costs nor do they consider oncological outcomes and quality of life impact.

Evidence was insufficient to define the learning curve for RALPN or the parameters around surgeon or hospital volume required for safe practice.

Identified research gaps

Randomised controlled trials are required to compare the clinical and cost effectiveness of RALPN with OPN and LPN. These should examine long-term oncologic outcomes including cancer recurrence and survival.

Equality and diversity

Healthcare Improvement Scotland is committed to equality and diversity in respect of the nine equality groups defined by age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion, sex, and sexual orientation.

The process for producing evidence notes has been assessed and no adverse impact across any of these groups is expected. The completed equality and diversity checklist is available on www.healthcareimprovementscotland.org

About evidence notes

Evidence Notes are produced to inform a decision at a particular point in time and are therefore not routinely updated. They will however be considered for review if requested by stakeholders, based upon the availability of new published evidence which is likely to materially change the advice given. For further information about the evidence note process see:

www.healthcareimprovementscotland.org/our_work/clinical_cost_effectiveness/shtg/standard_operating_procedures.aspx

To propose a topic for an evidence note, email shtg.hcis@nhs.net

References can be accessed via the internet (where addresses are provided), via the NHS Knowledge Network www.knowledge.scot.nhs.uk, or by contacting your local library and information service.

A glossary of commonly used terms in Health Technology Assessment is available from htaglossary.net.

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- Mr Michael Aitchison, Director Renal Cancer Services, Royal Free Hospital
- Karen McNee, Regional Development Manager, Kidney Cancer Scotland
- Mr Grenville Oades, Managed Clinical Networks Lead for Urological Cancer

Declarations of interest were sought from all peer reviewers. All contributions from peer reviewers were considered by the group. However the peer reviewers had no role in authorship or editorial control and the views expressed are those of Healthcare Improvement Scotland. The DOI Code of Practice is available from the Healthcare Improvement Scotland website.

Healthcare Improvement Scotland development team

- Lorna Thompson, Lead Author/Health Services Researcher
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- Members of the SHTG evidence review committee (membership details can be found on the Healthcare Improvement Scotland website)

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