Ir J Med Sci (2017) 186:1023–1026
DOI 10.1007/s11845-017-1562-7

ORIGINAL ARTICLE

A single centre experience of zero-ischaemia laparoscopic partial nephrectomy in Ireland

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Received: 13 October 2016 / Accepted: 11 January 2017 / Published online: 25 January 2017

Abstract
Background Nephron-sparing surgery in the form of partial nephrectomy is increasingly becoming the standard of care in patients with small renal tumours. Oncological outcomes for partial nephrectomy are equivalent to radical nephrectomy, however, clamping of the hilar vessels to allow resection of tumours during partial nephrectomy may cause ischaemic damage to the kidney and result in long-term renal impairment.
Aim We carried out a retrospective review of 43 patients undergoing laparoscopic partial nephrectomy (LPN) and assessed functional and oncological outcomes.
Methods The operative technique initially utilised a thulium laser, with later cases using the LigaSure™ vessel sealing device. All patients underwent preoperative cross sectional imaging and anatomical classification accordingly.
Results Forty three patients underwent LPN in our unit from 2006 to 2014. The mean (range) tumour diameter on preoperative cross sectional imaging was 28.2 (12–49) mm. All cases had a warm ischaemia time of zero, as hilar vessels were not clamped in any case. The mean (range) preoperative estimated glomerular filtration rate (eGFR) was 73 (37 to >90) ml/min/1.73 m^2 and was not significantly different to the post-operative mean (range) eGFR of 71 (31 to >90) ml/min/1.73 m^2. 34 (79%) of the tumours were found to be malignant. Positive surgical margins were found in one case. The mean (range) follow-up time in our cohort was 61.6 (24–127) months and no patient has had a local or distant recurrence.
Conclusion Zero ischaemia laparoscopic partial nephrectomy appears to be a safe and oncologically satisfactory procedure for the management of small localised kidney tumours.

Keywords Renal cell carcinoma · Laparoscopy · Partial nephrectomy

Introduction

Nephron-sparing surgery in the form of partial nephrectomy is increasingly becoming the standard of care in patients with small renal tumours [1]. This is based on the oncological equivalence and functional superiority of partial versus radical nephrectomy [2]. Minimally invasive surgery in the form of laparoscopic partial nephrectomy has been shown to be a valid alternative to open partial nephrectomy in the management of small renal tumours [3–7]. In a study of 2321 patients, those who underwent laparoscopic partial nephrectomy had less intensive care admissions and shorter median length of stay when compared with those who underwent open partial nephrectomy [8]. It has been suggested that clamping of hilar vessels can result in ischaemic nephropathy, causing long-term decline in renal function [9–11]. Studies of outcomes in zero-ischaemia laparoscopic partial nephrectomy show that small renal tumours can be managed with this approach, offering preserved perioperative outcomes, equivalent oncological outcomes and improved long-term functional outcomes [12, 13]. It has been suggested that those who benefit most from a zero ischaemia technique are those with the poorest baseline renal function [14]. However, laparoscopic partial nephrectomy is a technically challenging procedure and minimising warm ischaemia time can be difficult.

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We retrospectively assessed 43 consecutive patients undergoing zero-ischaemia laparoscopic partial nephrectomy in our institution and assessed functional and oncological outcomes in these cases.

Methods

Data were retrospectively collected and maintained on a secure departmental database. Inclusion criteria comprised an enhancing tumour suspicious for malignancy. No patient was excluded for reasons of tumour or technical complexity (i.e. had an open partial nephrectomy). All procedures were performed by a single surgeon (T.H.L) between March 2006 and September 2014. All patients underwent routine laboratory testing and cardiopulmonary evaluation. Estimated glomerular filtration rate (eGRF) was calculated using the Modification of Diet in Renal Disease (MDRD) equation. All patients underwent triphasic renal computed tomography (CT) scan with 3 mm axial cuts pre-operatively to assess tumour size, position, relation to collecting system and depth of extension. A Pre-operative Aspects and Dimensions Used for Anatomical classification (PADUA) score was calculated for each tumour, based on the cross-sectional imaging [15].

Operative technique in our unit has evolved over the duration of the study, with the first 16 cases being carried out using a 2013 μm Th:YAG laser (Revolix 120W surgical laser, LISA Laser Products). These cases were reported in a previous case series [16]. The subsequent 27 cases were carried out using the LigaSure™ vessel sealing device (Covidien), and ValleyLab™ argon beam plasma coagulation (Covidien). Standard operative technique in our unit involves a transperitoneal approach to the kidney, with the first port placed using an open Hasson technique and two further ports sited under direct vision. The colon is mobilised medially, the proximal ureter identified and retracted laterally. Cephalad dissection along this plane leads to the renal hilum. The renal artery and vein are then located, isolated and controlled using vessel loops (in case cross clamping is required during tumour resection). Gerota's fascia is then opened, the kidney mobilised and the tumour located. The margin of resection is then superficially marked with diathermy. The tumour is excised using a thulium laser in our initial cases, followed by the LigaSure™ vessel sealing device and argon beam coagulation in subsequent cases. The tumour is then removed via the 12–15 mm post using an endoscopic specimen bag. If resection of the tumour necessitates opening the renal collecting system, this is repaired with 2-0 polyglactin sutures. Haemostatic renorrhaphy is carried out using cellulose bolsters secured onto a 1-0 polyglactin suture using Hemo-o-lok clips. A Robinson's drain was placed in all cases.

Results

A total of 43 patients underwent zero-ischaemia laparoscopic partial nephrectomy. All cases had a warm ischaemia time of zero, as hilar vessels were not clamped in any case. Eighteen patients (41.9%) were female and 25 patients (58.1%) were male. The mean (range) age at diagnosis was 56 (34–76) years. The mean (range) post-operative hospital stay was 5 (2–17) days.

Twenty two cases (47.8%) were right sided tumours. The mean (range) tumour diameter on pre-operative cross sectional imaging was 28.2 (12–49) mm and mean (range) tumour diameter on gross pathological assessment was 25.9 (13–46) mm. The median (range) PADUA score was 8 (6–11). The mean (range) operative time was 172 (120–306) min. The mean (range) estimated blood loss was 341 (100–900) ml. No cases were converted to open surgery. Two patients had post-operative urine leaks that were recognised in the early post-operative period. One of these patients required insertion of a drain under radiological guidance. Three patients required a transfusion post operatively for symptomatic anaemia.

Overall, 34 (79%) of the tumours were found to be malignant. Pathological tumour T stages are summarised in Table 1. Further breakdown of tumour histological subtype is shown in Table 2. One patient had a positive surgical

Table 1 Pathological tumour stage and margin status

Pathological T stage	Number of patients (%)
T1a	31 (91)
T1b	2 (6)
T2	0
T3	1 (3)
Margin status	
Positive margin	1 (2)
Negative margin	33 (98)

Table 2 Tumour subtypes

	No. of patients (%)
Malignant tumours	34 (79)
Clear cell	25
Papillary	4
Multicystic	3
Chromophobe	1
PEComa	1
Benign tumours	9 (21)
Oncocytoma	6
Angiomyolipoma	2
Haemorrhagic cyst	1

Table 3 Pre- and post-operative changes in serum creatinine and estimated glomerular filtration rate (eGFR)

	Pre-operative	Post-operative (6 months)	Relative change (%)	*P* value
Mean serum creatinine (mmol/l) (range)	79 (48 to 167)	80 (50 to 199)	+1.3	NS
Mean eGFR (ml/min/1.73 m^2) (range)	73 (37 to >90)	71 (31 to >90)	−2.8	NS

margin following resection of a pT1a Fuhrman grade 2 tumour. The mean (range) follow-up time in our cohort was 61.6 (24–127) months and no patient has had a local or distant recurrence.

The mean (range) eGFR was 73 (37 to >90) ml/min/1.73 m^2 pre-operatively compared with a mean (range) eGFR of 71 (31 to >90) ml/min/1.73 m^2 6 months post-operatively (Table 3). The mean (range) serum creatinine was 79 (48–167) mmol/l pre-operatively compared with a mean (range) serum creatinine of 80 (50–199) mmol/l 6 months post-operatively (Table 3).

Discussion

Warm ischaemia time has been identified as a significant risk factor in partial nephrectomy and studies of nephron-sparing surgery in solitary kidneys initially suggested that warm ischaemia time should be limited to 20 min [17, 18]. However, a more recent meta-analysis of ten retrospective studies suggests that zero-ischaemia partial nephrectomy offers equivalent oncological outcomes and improved long-term renal functional outcomes [13].

Zero-ischaemia partial nephrectomy was initially described by Gill and colleagues [19] in 15 patients undergoing laparoscopic or robotic partial nephrectomy. Gill and colleagues induced hypotension via pharmacological agents to coincide with resection of the deepest part of the tumour. They also ligated the specific vascular branch supplying the tumour in those cases where the tumour was supplied by a dedicated arterial branch.

Studies of zero-ischaemia laparoscopic partial nephrectomy with larger patient numbers are lacking in the literature. There have been retrospective studies comparing zero-ischaemia laparoscopic partial nephrectomy to laparoscopic partial nephrectomy with clamping of the renal vessels. These studies have all suggested the renal functional outcomes are either equivalent or superior in zero ischaemia cases involving small renal tumours [11, 12, 20]. Some studies have suggested that larger tumours can also be managed using zero-ischaemia laparoscopic partial nephrectomy [10, 21]. However, most studies have involved significantly smaller patient numbers than those included in our study.

We have reported on a relatively large number of patients undergoing this procedure. Our operative, oncological and functional outcomes show that this is a safe and satisfactory procedure for the management of small localised renal tumours.

This study has limitations. Although our patient numbers are relatively large in the context of the available literature, more patients are being recruited to this study to reinforce the conclusions that can be drawn from this work. This study did not include a control group and a comparison in the context of a randomised control trial is needed.

Conclusion

Partial nephrectomy is the gold standard for surgical management of small renal lesions suspicious for malignancy. Zero ischaemia laparoscopic partial nephrectomy appears to be a safe and oncologically satisfactory procedure for the management of small localised renal tumours. Further cases and longer follow-up will define the accuracy of this technique in the Irish population.

Compliance with ethical standards

Funding There was no funding obtained for this study.

Conflict of interest No author has a conflict of interest to declare.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

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