The term small renal mass (SRM) is usually classified as a contrast-enhanced tumour within the kidney that is less than 4cm in diameter.1 Approximately 80 per cent of these represent a primary renal malignancy, but their growth pattern is often very slow, with a mean increase in size of around 2–3mm per year. Renal cancer is now the eighth most common cancer in the UK, accounting for 3 per cent of cancer diagnoses and 2 per cent of all cancer deaths in 2009.2

This rising trend has been observed worldwide and has followed advances in radiological imaging, with increased utilisation of ultrasound, CT and MRI, leading to two major consequences. First, detection of renal cell carcinoma (RCC) is increasingly incidental, occurring largely in asymptomatic patients undergoing imaging performed for non-specific abdominal complaints or other unrelated indications. Second, the increasing utilisation of imaging modalities has led to the average size of RCC at diagnosis decreasing towards smaller masses that are amenable to less radical interventions. The change in both incidence and detection size has created a shift in the treatment options for SRMs to meet the demand of the increasing number of patients that are candidates for nephron-sparing surgery (NSS) and minimally invasive therapies.

Technological progress has resulted in several minimally invasive surgical approaches for SRM excision, including laparoscopy and robotic-assisted surgery, as well as ablative therapies (Figure 1). However, technological advances in SRM therapy have far exceeded the rate of high-level evidence and thus no definitive SRM treatment protocol exists. The majority of guidelines support the trend toward NSS and minimally invasive strategies, but recent studies report an underuse of nephron-sparing techniques.

**IMAGING AND BIOPSY OF SMALL RENAL MASSES**

Although most contrast-enhancing renal masses are considered to be malignant, current imaging modalities (MRI, CT, ultrasound) cannot distinguish between...
benign and malignant tumour biology (Figure 2). A definitive diagnosis can be provided only by a percutaneous renal biopsy.

Biopsy is re-emerging as an established tool to characterise further the incidentally discovered SRM. The integration of clinical and histological information has the potential to increase our ability to tailor the best treatment for each individual.

Historically the use of percutaneous renal biopsy (PRB) was limited to exclude secondary metastases, lymphoma and renal abscesses. However, concerns over safety of PRB regarding tumour seeding and the serious risk of renal haemorrhage, given the extreme vascularity of the normal renal parenchyma and RCC, led to the near abandonment of PRB as a diagnostic tool for SRM.

Currently, PRB is the established diagnostic tool when a histological diagnosis would alter clinical management. This includes renal metastases in the presence of a known extra-renal malignancy, cases of ambiguous imaging and in elderly, comorbid patients in whom benign lesions would obviate the need for surgery.

Over the past decade, the role of PRB in the management of SRMs has been expanding rapidly. Lane et al. declared a ‘renaissance’ of PRB with their recent meta-analyses re-examining the precision of PRB, reporting that an accurate diagnosis could be made in 95 per cent of cases and that the false-negative biopsy rate was <1 per cent in this setting. Improvements in the needle design, including the advent of the coaxial technique, have minimised needle contact with the surrounding abdominal tissues, consequently lowering the risk of tumour seeding to less than 0.01 per cent, and no cases have been reported since 1994.

Differentiating between benign oncocytomas and RCCs in biopsy specimens continues to pose a major diagnostic challenge. Increasingly it is advocated that an undiagnostic biopsy should be followed by repeat biopsy as the success rates are similar

Although OPN has been largely superseded by laparoscopic partial nephrectomy (LPN) and robotic-assisted partial nephrectomy (RAPN), it remains the preferred approach for complex and multiple renal neoplasms, tumours in solitary and poorly functioning kidneys and where minimally invasive surgery is not available.

Laparoscopic partial nephrectomy
LPN seeks to replicate the fundamental oncological principles of OPN while incorporating a minimally invasive approach, with the aim of improving perioperative outcomes. Several studies have reported the potential benefits of LPN, including decreased operative blood loss, rapid convalescence, improved cosmesis and reduced postoperative pain.

However, LPN is associated with a higher rate of perioperative complications, mainly relating to postoperative haemorrhage (18.6 versus 13.7 per cent). Furthermore, tumour size correlates with complication rates, with cortical and exophytic tumours associated with a lower risk. The technically challenging nature of laparoscopic surgery has an established steep learning curve; Simmons et al. revealed that a significant reduction in complication rates could be reached only after >200 cases. In fact, current guidelines recommend careful patient selection based on tumour size and location in the early phases of a surgeon’s learning curve in order to reduce LPN complications.

The second major concern highlighted in the majority of case series investigating LPN is the longer reported warm ischaemia times (WIT) compared to OPN. A multicentre study by Gill et al. found that WIT was 30.7 min for LPN but only 20.1 min for OPN.

Robotic-assisted partial nephrectomy
With more than 2000 systems sold worldwide, the da Vinci robotic system (Intuitive Surgical, Sunnyvale, USA) has several potential advantages over standard laparoscopic approaches. Gettman et al. first published a report on RAPN in 2004, and it is rapidly
gaining acceptance as the next technological revolution in the treatment of SRM.\textsuperscript{10}

The largest multi-institutional comparison of LPN and RAPN in 2009 reported no significant differences between the two procedures regarding overall operative time (189 versus 174 min), positive margin rate (3.9 versus 1 per cent) or length of hospitalisation.\textsuperscript{11} However, the authors observed that WIT was much shorter in the RAPN group than LPN regardless of tumour complexity (15.3 versus 25.2 min for simple tumours, \textit{p}=0.0001; 25.9 versus 36.7 min for complex tumours, \textit{p}=0.0002).\textsuperscript{11}

WIT is often the principal theme of studies conducted on minimally invasive NSS, as WIT reduction has been shown to correlate with increased renal functional reserve; recent data suggest an ideal WIT of <20 min for maximal renal preservation.

A single surgeon series reported that learning curves for WIT in LPN were not reached until >565 procedures, whereas the equivalent WIT outcome in RAPN was met in multiple studies after only \textless 30 procedures.\textsuperscript{12} A possible explanation for the shorter learning curve of RAPN relative to LPN is the practical advantage of robotic assistance, even for surgeons without extensive experience in minimally invasive surgery. The da Vinci surgical system offers surgeons a stereoscopic, three-dimensional view with the use of ergonomic and fully articulating instruments allowing seven degrees of freedom with tremor elimination. These unique features can ease the technical challenges associated with the complex procedures in minimally invasive NSS, particularly in tumour excision and closure of the renal defect (renorrhaphy) through improved precision, visualisation and dexterity.

In spite of its numerous benefits, the use of robotics has raised several contentious issues, the most evident being the initial high cost of installing and maintaining the robotic system (approximately £1.6 million). In addition, concerns have been raised over the increased reliance on the surgical assistant in performing key manoeuvres such as placement of surgical clips and vascular clamps and concerns in the event of surgical mishap when the surgeon is unscrubbed and away from the bedside. However, as RAPN in still its infancy, novel techniques are constantly evolving, such as robotically applied bulldog clamps, to restore surgical control and, as popularity increases, further refinements and adjuncts to the technique are likely to resolve other concerns.

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### ABLATIVE THERAPIES

Several ablative therapies have been explored in the literature, but only radiofrequency ablation and cryoablation have had widespread use. Ablative therapy presents several advantages to NSS, including the ability to treat high-risk surgical patients in an outpatient environment, greater patient tolerance and a greater nephron-sparing ability than surgical excision. Often a tumour biopsy is performed simultaneously at the time of the ablative therapy.

**Radiofrequency ablation**

Radiofrequency ablation uses a needle probe to convert radiofrequency waves to heat tumour tissue using temperatures >50°C, causing cell death and coagulative necrosis. A large series examining radiofrequency ablation in 243 renal tumours over a period of 7.5 years reported an initial successful ablation rate of 97 per cent, and a five-year disease-free survival rate of 93 per cent.\textsuperscript{13}

**Cryoablation**

Cryoablation uses several hollow needles inserted into the kidney, through which cooled, thermally conductive fluids are circulated; this causes tumour ablation by direct cellular injury through swift freeze–thaw cycles using temperatures between −20°C and −50°C. It can be performed percutaneously or laparoscopically. A retrospective report of 131 cryoablations of 123 patients reported high cancer-specific survival rates of 100 per cent, with none of the patients experiencing recurrence at the five-year follow-up.\textsuperscript{14}

In spite of the overall high disease-free survival rates for both radiofrequency ablation and cryoablation in the literature, local progression rates are poorer than for NSS, with metastatic progression occurring in 1.2 per cent of cases after cryoablation and 2.3 per cent of cases after radiofrequency ablation.\textsuperscript{14}

However, data on success rates for ablative therapy should be interpreted with caution as non-standardised criteria have been used to define success in each study. The majority of authors used lack of contrast enhancement on MRI or CT to measure treatment effect. This lack of uniform radiological criteria of successful ablation has raised doubts of the true clinical efficacy of ablative therapies. The poor correlation between imaging and residual tumour can be clarified by post-ablation biopsies, but these are rarely performed.

Although ablative therapies are a promising alternative treatment for SRMs, extended oncological data need to be established to quell concerns over local recurrence and often these treatments are reserved for elderly and comorbid patients.

**ACTIVE SURVEILLANCE**

Active surveillance is the serial monitoring of tumour growth by sequential radiological imaging with intervention limited for those SRMs that show tumour progression at follow-up.

The rationale for active surveillance is founded on the hypothesis that the general slow growth and low metastatic rates of SRM may nullify the beneficial impact on overall survival rates of active SRM treatment in elderly and comorbid patients with a shorter life expectancy. Data from a
The majority of small renal masses are incidentally detected as a consequence of the extensive use of modern radiological imaging.

Nephron-sparing surgery is an established curative approach for small renal tumours; approaches include robotic, laparoscopic and open partial nephrectomy.

Percutaneous renal biopsy is re-emerging as a diagnostic tool to establish the histology of small renal masses and serves as a practical complement to guide clinical treatment decisions.

Minimally invasive treatment options including radiofrequency ablation and cryoablation are emerging but are currently reserved for older and co-morbid patients.

The role of active surveillance is limited to elderly patients with shorter life expectancies and poor surgical candidates.

Prospective multicentre trial investigating active surveillance of 178 elderly patients found that progression to metastasis occurred in only two patients (1.1 per cent). Although adverse events are rare, disadvantages include a small but real risk of cancer progression, possible loss of window of opportunity for NSS and lack of curative salvage therapy if metastases occur. Active surveillance remains a relatively experimental treatment strategy and there is no clear consensus over the optimal imaging methods or follow-up schedule. However, it is currently considered an appropriate treatment strategy in a highly select group of patients consisting of elderly, frail and comorbid patients and high-risk surgical candidates.

**DISCUSSION**

Controversies over the treatment of SRM have developed with the paradigm shift from radically to minimally invasive and percutaneous therapies, resulting in clinicians having an extensive array of treatment options.

PRB is re-emerging as an established tool to characterise further the incidentally discovered SRM. RAPN, where available, is overtaking OPN as the standard of care for incidental, small and exophytic SRMs. There is a transition from laparoscopic techniques towards more robotic procedures, with continued familiarity with the robotic technology and increased case volume producing more rigorous supportive data. Removal of complex tumours may require a longer ischaemic time; this is still performed using an OPN approach combined with ice-slush renal hypothermia. Ablative therapies in addition to active surveillance remain confined to the treatment of select groups of patients at the extremes of age and morbidity.

The final interventional choice is down to an interplay between patient factors such as age, comorbidities, size and location of the tumour, and urologist factors such as training, experience and availability of technology. One thing is certain, the incidence of SRMs will continue to rise, producing more rigorous supportive data.

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