

Minimally invasive surgery in management of renal tumours in children

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Abstract: Minimally invasive surgery (MIS) in the management of malignant and benign renal tumours in children is gradually becoming more common. Experience is limited and restricted to case reports, retrospective chart reviews and a few cohort studies. There are currently no randomized controlled trials or controlled clinical trials comparing the laparoscopic and open surgical approach for the management of renal tumours in children. MIS may offer the same oncologic outcome in malignant renal tumours whilst providing the advantages associated with MIS in correctly selected cases. The technique for tumour resection has been shown to be feasible in regards to the recommended oncologic principles, although lymph node sampling can be inadequate in some cases. Preliminary reports do not show an increased risk of tumour rupture or inferior oncologic outcomes after MIS. However, the sample size remains small and duration of follow-up inadequate to draw any firm conclusions. Implementation of MIS is lacking in the protocols of the major study groups, and standardized recommendations for the indications and contra-indications remain undefined. The objective of this article is to present a review of the literature on the role of MIS in the management of renal tumours in children, with the main focus on Wilms' tumour (WT). Further studies on MIS in renal tumours are required to evaluate the incidence of oncological complications such as complete tumour resection and intra-operative tumour spillage. A long-term follow-up of patients managed by MIS is essential to compare recurrence rates and overall survival rates.

Keywords: Laparoscopy; paediatric; renal; tumour; minimally invasive surgery (MIS)

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Introduction

Renal tumours account for about 7% of all tumours in children before the age of 15 years. Wilms' tumour (WT), or nephroblastoma, is the most common primary renal neoplasm in childhood with an incidence of 1 in 10,000 (1-3). The most common presenting sign is an asymptomatic abdominal mass in a child between 2 and 4 years old. Most WT occur as solitary lesions, but 6% present with bilateral disease and 12% with multifocal disease within a single kidney. Some children have a predisposition to

developing WT. Syndromes associated with WT include Beckmann-Wiedemann, Denys-Drash, Li Fraumeni and neurofibromatosis (4), and patients with these syndromes are required to undergo periodic screening with renal ultrasound. Other less common renal neoplasms in children include clear cell kidney sarcoma (CCKS), renal cell carcinoma, malignant rhabdoid tumour of the kidney and mesoplastic nephroma. Metanephric adenoma is a benign renal tumour that can occur in children (2).

The survival rate in children with WT has increased dramatically over the past 5 decades, and is now around

90% for patients with low stage (I and II) disease and a favourable histology of the tumour (5,6). Large multi-centric randomized controlled trials have been published on the general management of WT and other solid tumours. Two major groups that have contributed greatly in the successful management of WT are the European International Society of Paediatric Oncology (SIOP) and the North American Children's Oncology Group (COG) [which includes the former National Wilms' Tumor Study Group (NWTSG)]. There are also independent national study groups. The guidelines for management of WT are well established. Radical open nephrectomy is fundamental in management of WT in combination with chemotherapy and in some patients, radiotherapy. There has been and still are continuing improvements and developments in every treatment aspects, both in combination and within each field, assuring regular update of the treatment protocols.

The great success achieved in reducing mortality is redirecting the attention towards treatment options which may minimize the surgery related morbidity without impacting the event-free survival. Surgical technology is constantly in development, facilitating the introduction of new instruments and techniques to almost all surgical fields. Minimally invasive surgery (MIS) has been utilized for decades in the adult patient group, however lagging behind in the paediatric patient group. With development of new and smaller instruments (1,7,8) and increased experience among surgeons in the field, laparoscopy has gained widespread popularity in standard as well as complex operations in children. Range of conditions successfully managed by MIS is rapidly growing, including urological conditions such as pyeloplasty and nephrectomies for non-functioning kidneys and polycystic kidney disease (9,10). Despite the increasing utilisation of MIS in paediatric surgical oncology, the international multi-centric trial groups have not yet investigated the role of MIS within the guidelines and recommendations.

The aim of this article is to review the existing literature on the experience of MIS for renal tumours in children, the advantages and concerns, and to compare the outcomes with the traditional open nephrectomy.

Current management of WT

Neo-adjuvant chemotherapy is the gold standard in treatment of WT in the SIOP protocol. Four weeks pre-operative Vincristine and Actinomycin D in patients with localized tumours, 6 weeks and the addition of Doxorubicin

in cases of metastatic tumours. The aim of the neo-adjuvant chemotherapy is down staging, shrinkage of tumour and reduction of surgery-related complications. The chemotherapy induces a pseudo-capsule that is important in preventing intra-operative tumour rupture and subsequent spillage, and is especially of advantage in cases of larger tumours and where nephron-sparing surgery (NSS) may be indicated (7,11-13). The essential difference in the COG protocol is that most patients are treated with immediate surgery and then chemotherapy. Tumour rupture has been shown to occur during open radical nephrectomy (ORN) in 2.8% of the cases in the SIOP-9 protocol (14), compared to 11% of the patients treated with upfront ORN in the NWTSG-4 protocol (15). Arguments for the strategy in this protocol are risks associated with the chemotherapy, including administration to patients with benign tumours or other malignant tumours than WT, modification of histology and loss of staging information. Nevertheless, the oncologic outcomes are excellent regardless of utilized protocols (13,16).

Post-operative treatment is based on histological staging and tumour histology. The system used by SIOP is based on staging following pre-operative chemotherapy. The current staging system used by COG is based on findings of primary surgery, and also includes five stages. The tumours are then separated into one of three groups depending on prognostic risk factors of the histology type; low, intermediate or high risk. The risk stratification has proved to be prognostically more important than the stage. Common protocols for post-operative chemotherapy include Vincristine, Actinomycin D and Doxorubicin. Other options for tumours of higher risk/stages include different combinations Carboplatin, Cyclophosphamide and Etoposide (13). Low-dose radiation therapy (RT) may also be indicated in selected groups with higher stage disease or higher risk (5,13).

Open radical nephrectomy

Open radical nephrectomy is the gold standard in unilateral cases of malignant renal tumours in children. The recommended surgical technique is defined by the SIOP 2001 protocol. The abdominal cavity is opened using a long transverse abdominal incision or a Chevron incision. The renal vessels are ligated early to avoid swelling of kidney, which increases the intratumoural pressure, and the risk of tumour rupture. The tumour and the adipose capsule, with all surrounding structures, are removed if achievable. Inspection of the entire abdominal cavity is performed,

including the renal veins and vena cava. Hilar and para-aortic lymph nodes are sampled for histology. The opposite retroperitoneal space must be assessed if pre-operative CT or MRI indicates bilateral tumour (14,17).

Laparoscopic nephrectomy (LN)

MIS is increasingly being used to treat malignant renal tumours in children, but the numbers are small. The basic tenets of MIS must adhere to oncological principles. This includes the ability to completely remove neoplasm without rupture of tumour, assess the entire abdominal cavity to detect metastasis and to perform adequate lymph node sampling (12,18). Complete surgical resection is one of the strongest predictors of outcome in WT (19).

LN in renal tumours in children is more commonly performed via the trans-abdominal approach (11,19,20), though cases are reported utilising the retroperitoneal approach (21,22). A systematic review and meta-analysis of available publications in the adult literature compared the outcomes of these two approaches and there were no differences in safety and efficacy of these two methods (23). Three or four trocars are commonly utilised. The specimen is usually placed within an endoscopic retrieval bag to avoid tumour rupture and spillage. The bag containing the specimen is then removed through a Pfannenstiel incision. This reduces the risk of rupture and allows adequate inspection of the tumour margins and accurate histological staging of the tumour (8,12). The incision is smaller and located in a more concealed area compared with ORN (11,20). The other option for specimen removal is to extend the incision of one of the port sides, usually the umbilical, and remove the tumour by morcellation. This has been associated with increased risk of disseminating tumour mass to the abdominal cavity through breakage of the endoscopic bag and is generally not recommended (20).

The advantages of MIS are well known, with good outcomes in the paediatric population in relation to recovery and surgical morbidity (12,24). Kim *et al.* compared the different surgical approaches to paediatric nephrectomy in children [open surgery, transperitoneal laparoscopy, laparoscopic single site surgery (LESS) and robotic surgery] and included 69 patients in their study. The minimally invasive modalities were associated with shorter length of hospitalization and reduced post-operative analgesic requirements, but were noted to have slightly longer surgical times than open surgery. The difference in surgery time was partially attributed to learning curve factors (9).

Another study showed significantly reduced mean hospitalization in thirteen patients that underwent LN for WT (2.9 *vs.* 5.9 days) compared with 32 patients whom underwent ORN, and significantly shorter duration of nasogastric tube in the LN group. Almost all the patients in the ORN group received epidural block versus none in the LN group, however duration of post-operative narcotics were not significantly different (12). Studies have shown better pulmonary function, earlier return of bowel function and more rapid normalisation of the immune function after MIS. The risk of wound infection is reduced, and a ten-fold decreased risk of incisional hernias has been reported (24,25). The rapid recovery that follows MIS has the additional benefit of an earlier start of chemotherapy and radiotherapy post-operatively, potentially improving the prognosis for patient following MIS (1,20,24,26). The short-term advantages of a quicker recovery in MIS may be less in children when compared to adults, as children recover faster following an open procedure. Laparoscopy is also associated with lower hospital costs (25,27).

Post-operative complications such as adhesive bowel obstruction and intussusception have also been shown to be reduced (20,27). Incidence of bowel obstruction following ORN in the NWTs-3 was 5.4% and 2.5% in the SIOP-9 trial, and the incidence of intussusception 1.1% in after ORN in the SIOP-2001 study (15,28). To our knowledge, no cases of intussusception or bowel obstruction after LN for renal tumours in children have been reported in literature so far.

Another advantage is the cosmetic outcome, as small incisions result in reduced scarring on the abdomen than the open surgical approach. Kinahan *et al.* reviewed 14,358 survivors of childhood cancer through self-reporting on scarring and disfigurement and persistent hair loss, and compared the answers with 4,023 siblings. The cancer survivors reported a significantly higher rate of scarring/disfigurement for chest/abdomen (29).

There are several possible disadvantages of MIS in management of renal tumours. The surgical technique is considered to be technically more challenging when compared to the open approach. Limitations of MIS are tactile deficit and limited visualization of lesions not located on the organ surface. Distinguishing tumour from unaffected tissue can be very difficult, with the potential consequence of incomplete resection of neoplastic tissue and damage of healthy organs (19).

Clearly, an inferior oncological outcome is the main concern. Negative impact on event-free survival and

overall survival would be unacceptable due to the already successful outcome in WT managed by the open approach. Fearsome oncologic complications are tumour rupture with subsequent spillage, and incomplete resection of the tumours (15,18,19). These events would upstage the tumour, and add the burden and possible long-term morbidity of intensive adjuvant radiotherapy and increase the chance of cardiotoxic chemotherapy to the patient (12,27). The long-term consequences are the increased risk of local recurrence of the disease and peritoneal metastasis. Tumour spillage results in a six-fold increase in local recurrence in abdomen (18), and local recurrence is associated with poor prognosis, especially at higher stages (27). The recurrence rate was 2.7% in the SIOP-9 protocol (19) and 4.3% in the NWTSS-4 protocol (18). Incomplete resection is an independent risk factor for local recurrence in WT (30).

Duarte *et al.* have reported on MIS for WT resection in Brazil. In this retrospective study 17 patients were included in the LN group. Statistical analysis showed no difference regarding death, relapse and the need for radiotherapy, at follow-up at 4.3 years compared with the ORN group (11). The SIOP Renal Tumour Study Group (RTSG) analysed oncological and surgical outcomes in 24 patients who underwent LN for WT in the SIOP 2001 trial. The treatment results were comparable to those of open surgery in terms of event-free and overall survival at median follow-up at 47 months, and there were no intra-operative tumour ruptures. The surgeons in the trial had above-average experience with WT. Interestingly, lymph node sampling was performed in only 15 of the 24 children and in only two patients were more than six lymph nodes sampled (7). Other studies have also reported on LN as safe and feasible in management of renal tumours, with no incidents if tumour ruptures. The results were similar in regards to surgical complications, tumour recurrence and event-free survival at follow-up compared with open surgery (1,12,20,27).

Port-site metastasis is another feared complication, which was discovered after the initial laparoscopic procedures were performed on abdominal neoplasms in the adult population and led to concerns regarding long-term survival (11). Guidelines for laparoscopic oncology were developed, and the rate reduced dramatically. Among the recommendations were the introduction of impermeable retrieval bag for specimen extraction, CO₂ exsufflation by the trocars and excision of the trocar edges if doubt (27). Chui *et al.* described a case of peritoneal diffusion with port-site and peritoneal metastasis after laparoscopic NSS for WT in a 2-year-old girl. The tumour size was 10 cm

(significantly larger for her age), of favourable histology without anaplasia. Of note, neo-adjuvant chemotherapy was not given, lymph node sampling was not performed and it was unknown if a retrieval bag was used. Post-operative chemotherapy was commenced 6 weeks post-operatively and no radiotherapy was given to the patient (31). To our knowledge, no other cases of port-site recurrence have been reported in patients treated with MIS for WT, and reports are not indicative of port-site recurrence in laparoscopic procedure in paediatric malignancies, however long-term follow-up is lacking (32).

LN has commonly been performed after pre-operative chemotherapy according to the WT SIOP protocol (11,17,27). Cases undergoing LN without preoperative chemotherapy using the COG protocol have also been reported. Romao *et al.* compared ORN and LN over a 5-year period. They examined 13 patients with renal tumours managed by LN and only two patients underwent pre-operative chemotherapy. There was no evidence of intra-operative tumour rupture at the time of the surgery. However, one patient had a local recurrence and a possible cause was a tear in the retrieval bag. Recurrence rates were similar in both patient groups (12). Barber *et al.* also presented two patients undergoing upfront LN for WT, aged 14 months and 16 years, with 8-cm lesions. There were no tumour spillage and no other complications (33).

Most studies have focused on the utilization of MIS in a highly selected group of patients, and metastasis is generally considered to be a contra-indication for MIS. Javid *et al.* described a case of WT in a 2-year-old child with a large renal mass, peritoneal seeding in pelvis and disseminated pulmonary metastatic disease. Pre-operative chemotherapy successfully reduced the sizes of the lesions, and all remaining lesions were removed in the same surgery by minimally invasive approach. The patient is disease-free at 19-month surveillance. The authors highlighted the magnifying view with visualization of tumour and metastatic disease as a great advantage, in particular the ability to remove multiple small tumour implants in the deep pelvis (26).

Operative time has been reported to be longer in LN for WT, though no significant difference has been shown (11,12). Nevertheless, mean operative time of the procedures varies greatly among studies, from 97 (20) to 282 minutes (12).

Robotic techniques for renal cell carcinoma in adults are applied to both radical and partial nephrectomy in various procedures (34). Recent technological advances have led to an introduction of options for urological procedures

in children. Advantages are magnified three-dimensional visualization and improved wrist-like instrument control that facilitates in particular intracorporeal suturing and reconstructive procedures (9). Very few cases of the robotic approach in paediatric oncology have been described. Cost *et al.* have presented two separate cases on robotic-assisted surgeries in renal tumours in the adolescent population. Firstly, a pre-chemotherapy robotic-assisted radical nephrectomy was described in a 14-year-old patient with WT, without intra-operative tumour rupture and with negative surgical margins. Information on outcome at follow-up was not included (35). Secondly, a renal cell carcinoma measuring 1 cm in a 14-year-old was managed with robotic-assisted NSS. Partial nephrectomy and an extended full aortic and hilar lymph node dissection were successfully performed. A lesion of the pancreatic head was found on 6 months surveillance, and she was later diagnosed with MEN type 1. The authors highlight the suturing of the remaining renal tissue or vascular injury as particular advantages of the robotic approach (36).

Another recent introduction to the minimal invasive approaches is the LESS, laparoendoscopic single stage approach. Cases of successful nephrectomy have been reported (9). To our knowledge, no case reports utilising LESS in renal paediatric oncology have been published.

NSS

Data in adult patients has demonstrated that NSS is associated with improved renal morbidity and has a significant advantage with reduced postoperative CKD when compared with radical nephrectomy (37). NSS was first introduced to children with benign conditions with the aim to preserve renal function, before COG and SIOP included NSS as a surgical option in a highly selected group of patients with bilateral malignant renal disease by sparing non-cancerous renal parenchyma. Suggested candidates include patients with increased risk of recurrent disease (i.e., syndromic Wilms'), bilateral Wilms' or in case of concurrent contralateral urological and nephrological disorders (16,38). Ultrasound screening of patients with increased risk of WT facilitates detection of disease at an earlier stage, with sizes of tumours possibly amenable for NSS. Also, due to increased risk of metachronous WT, the risk of renal impairment is increased (16).

Wilde *et al.* showed that nephron-sparing resections in unilateral WT had oncologic outcomes comparable to patients after ORN (100% OS, 93.5% event-free survive at

5 years). Surgical complications were more common (11% vs. 5%). Selection of patients is crucial, and only 3% of the patients in the study had NSS (39). Cost *et al.* reviewed oncologic outcomes in patients treated off-protocol with NSS for non-syndromic unilateral WT. NSS compared favourably against ORN, but only in localized disease (no invasion of renal vessels or surrounding organs) (16).

Laparoscopic partial nephrectomy (LPN) is increasingly performed in benign conditions in paediatric urology (9) and considered to be the treatment of choice for most amenable T1 renal tumours (the tumour is confined to the kidney and less than 7 cm) in adults (34). A review of 1,375 adult patients that underwent LPN in Japan demonstrated that LPN was successfully completed in 93% of the patients. Post-operative haemorrhage, as the most important urological complication, occurred in 2.9% of the patients (40). There are only a few reports on LPN performed for malignant tumours in children. Piché *et al.* described a case of a small polar WT in 2-year-old girl with BWS in Canada. Neo-adjuvant chemotherapy was given, and laparoscopic nephron-sparing resection was performed through retroperitoneal approach. Resection margins were negative and she was recurrence-free at 6 months follow-up (22). Ozden *et al.* reported on two patients aged 10 and 14 years old who underwent laparoscopic NSS for metanephric adenoma. The largest tumour measured 67 mm in diameter. One re-attended on day 8 post-operatively, and required angiographic embolization for complication with pseudo aneurysm in the renal parenchyma (30).

Proposed inclusion criteria include a small tumour that is well circumscribed, preferably with a polar location and without any vascular involvement or metastasis (30). Pre-operative chemotherapy is commonly administered prior to NSS for WT, to reduce risk of tumour rupture. More than 50% of renal tissue should be spared in the surgery to give protection against hyper perfusion (14,16,28,30,41). Disadvantages for laparoscopic NSS in WT are tumour spillage, risk of peritoneal and port site metastasis, and surgical difficulties requiring high expertise and experienced surgeons (22,30). A problem occurs in case of positive surgical margins or neoplasm in sampled lymph nodes after NSS for WT, which would upstage the tumour and require more intensive adjuvant treatment. Radiotherapy would counteract the functional benefits of NSS (14).

Sampling of lymph nodes

Sampling of lymph nodes is essential for accurate staging,

risk stratification and in choosing the correct adjuvant treatment approach to minimize the risk of a local relapse (24). Absence of lymph node sampling is associated with increased risk of abdominal recurrence, and should mandate treatment as stage III disease to avoid under treatment (8,17,27). Lymph node metastasis and local residual disease have a negative impact on overall and event free survival in WT patients (42). There has been a controversy if the number of lymph nodes resected is associated with 5-year survival rate, as two large studies have had different conclusions. Zhuge *et al.* reviewed available lymph node data in 1,340 patients, and reported a significantly lower 5-year overall survival for patients with absent lymph node sampling (87%) versus patients with more than ten lymph node sampled (95%) (43). Kieran *et al.* concluded however that number of lymph node sampled did not change 5-year survival variation in their review of 3,409 patients, and found that only patients with anaplastic tumours had greater effect on lymph node positivity. The study demonstrated nevertheless, the importance of lymph node sampling for staging purpose, though not evidence that would justify recommendations on radical lymph node dissection (44).

The recommended number of lymph nodes might be undefined, though consensus is that sampling of periaortal lymph nodes must be sampled regardless of surgical approach. There are concerns regarding inadequate lymph node sampling in MIS (18). Studies have reported that lymph node sampling is feasible utilizing the laparoscopic approach, however compared to open surgery the number of lymph nodes sampled tends to be lower. The reasons for this remain unclear, and no specific comments or explanations for lack in sampling have been described in these studies (7,12,45).

Comparison with renal tumours in adults

LN for stage T1/T2 renal cancer (tumour confined to the kidney) in adults has gained widespread popularity, and has surpassed open surgery as the most frequent surgical technique. Both LN and robotic-assisted techniques are utilized in partial and radical nephrectomy of procedures also of complexity (34,40). Reports including more than 100 cases in a multi-institutional study prove LN to be safe and efficient, with equivalent recurrence rates as for open surgery (46). Comparison with the paediatric population is controversial in many cases, as there are differences in tumour biology, size of patients, size of instruments and prognosis (25). Another important aspect is the tumour size

on presentation. The incidence of small renal tumours in adults is high, hence amendable to either NSS surgery or LN. Patients with WT, on the other hand, often have large tumours on presentation (12).

Comparison with other paediatric solid tumours

A Cochrane review was published in 2015 on MIS compared with open surgery in treatment of solid abdominal and thoracic neoplasms in children. No randomized clinical trials or controlled clinical trials were identified and thus the evidence was insufficient to draw any conclusion on the topic (25).

Nevertheless, laparoscopy is performed in management of solid tumours in children. Several small case series have been published on the laparoscopic approach for tumour biopsy, exploration and for tumour resection (45). Tumour resections of a selection of thoracic, pelvic and abdominal tumours have been described (25,45), including successful results in cases of adrenal neuroblastomas (47). The success rate seems higher in cases of smaller tumours, and experience with MIS in metastatic disease remains highly limited. Laparoscopic approach is described as feasible without violating the general surgical principles in tumour clearance; however liberality in conversion to the open approach is highlighted. As with other literature on laparoscopic surgery in general, rapid recovery time and good cosmetic results have been observed (8,19). Nevertheless, the sample sizes remain too small to generate reliable conclusions.

Jones and Cohen performed a survey on surgeons' opinion of minimally invasive paediatric surgery in common paediatric conditions in Australia. One hundred and seventeen paediatric surgeons in Australia and the Pacific countries completed an anonymous web-based questionnaire, whereas 85% had more than 5 years of experience in MIS. WT is among the four conditions that scored highest on negative recommendation for MIS. Only five surgeons would perform MIS in WT and ten would recommend, but not perform MIS. Ninety-seven surgeons (87%) did not think MIS would be indicated in management of WT, 51 of these classified as "senior" paediatric surgeons (>20 years of experience) and 46 were classified as "junior" paediatric surgeons (<20 years of experience). In comparison, only one and eight surgeons considered MIS not to be indicated in cholecystectomy and undescended testicles respectively (48).

Discussion

MIS is a surgical option in the management of carefully

selected paediatric renal tumours. Improvements in instrumentation, imaging and increased technical laparoscopic experience among paediatric surgeons have been important factors that have allowed this development (24). Although surgical feasibility is not the main focus management of oncological patients, it seems likely that the use of laparoscopy in the treatment of renal tumours will further increase as it has done in the management of benign conditions in children. As the new generations of surgical trainees are exposed to higher volumes of MIS in the management of benign conditions the number of MIS procedures performed for renal tumours is also likely to increase. It is however of great importance that the emphasis of surgery in these children is not the feasibility, but management in accordance to the strict oncological principles (18). A surgeon performing these operations should have adequate experience in both laparoscopy and open oncological surgery. As often observed when utilising new surgical techniques, most complications occur during the learning curve, and experience is required to overcome the challenges (13). The limited number of cases in renal tumours in the paediatric field will prolong the learning curve (25). One can rightfully raise concerns over the impact of an experimental process through a learning curve. There is a higher threshold for safety and experience for the paediatric patient group, in particular due to vulnerability and life expectancy.

Controversy continues to remain as to whether the laparoscopic approach is an alternative to the open approach in the surgical management of paediatric renal tumours. Although the literature reports on a low incidence of surgical complications that are comparable the open approach, the number of patients is too small to draw any valid conclusions. There are to this date no randomized clinical trials comparing MIS with open approach in WT, as is the case in other paediatric solid tumours (25). The published studies have several limitations worth mentioning, including small sample sizes and lack of control groups. The patients are not randomized, and the studies are not blinded. Inclusion criteria used is often different and utilisation of neoadjuvant chemotherapy varies. In general the patients undergoing MIS have a better prognosis as these carefully selected cases tend to have smaller localised tumours, and thus outcomes will be biased. Furthermore, suboptimal results and unacceptable rate of complications may be underreported, if studies are either not submitted or publications not accepted (49). Post-operative management in relation to narcotic medication, nasogastric tube and

length of stay is affected by the surgical modality (12). Important data including information about surgical decision making in choice of MIS, details of surgical techniques, insufflation parameters, number of trocars, modality if specimen removal, sampling of lymph nodes and utilisation of adjuvant radiotherapy and chemotherapy is often lacking (7). The length of follow-up is also inadequate in the vast majority of cases with respect to oncological consideration (7,27).

As commonly seen in paediatric surgical subspecialties, new approaches in children mirror adult developments albeit with a delay in its introduction. Most studies have not been able to incorporate the rapid development of technical innovations and surgical advances making MIS in solid tumours more feasible. MIS has not played a role in paediatric urological oncology until recently. The SIOP RTSG have also reported on a lack of relevant data making comparisons difficult between the patients included in the study, considered to be because MIS played a small role at the time (7).

The role of MIS in paediatric solid tumours remains unclear. Patient selection seems critical, and there are still several questions that are unanswered. The choice of surgical technique, the selection criteria in patients, if pre-operative chemotherapy should be mandatory and the retrieval method are just a few of the aspects that need further clarification.

Indications or recommendations for MIS in renal tumours remain undefined (26,33). The majority of studies published have naturally included size of the tumour as an important factor. The risk of rupture increases with larger tumours, and the initial approach to renal vessels without mobilisation of the kidney is essential. The approach must be converted to open if the tumour mass cannot managed laparoscopically. It is suggested however, that adding a fourth or fifth trocar could facilitate laparoscopic removal of a larger tumour, however operative time would likely be prolonged and procedure could become more unsafe (20,27). Duarte *et al.* suggested inclusion of patients with tumour dimension/height ratio <10% (50). Others have focused on the distance from lateral aspect of vertebra on CT (7,27), or tumour size <10 cm (12). The age and the size of the patient are also important factor to consider. Older children and adolescents have proportionally larger working space similar to that found in adults. From a pathological perspective, the spectrum shifts from WT to renal cell carcinoma that tends to present as a tumour of smaller size (2).

The location of the tumour is important, and polar

tumours are easier to treat surgically and more amenable to MIS. Findings of locally advanced tumour and metastatic disease will usually exclude the option of MIS. It has been argued however that MIS could be indicated if there are large lymph nodes observed on the abdominal CT scan, as post-operative radiotherapy is likely to be required (27). Vena caval thrombus is generally considered a contra-indication for MIS in renal tumours, however a case of WT with renal vein thrombus has been successfully treated with a 3-port retroperitoneal laparoscopic technique (21).

The potential of laparoscopic nephron-sparing approach to renal tumours in children is highly uncertain, although the procedure is well accepted in adults; MIS in NSS could be an alternative approach however in a highly selected patient group. Improvement in identification of benign renal tumours, which were usually classified as or treated as malignant tumours, could potentially increase the number of patients eligible for minimally invasive partial nephrectomy (30). Open partial nephrectomy or laparoscopic radical nephrectomy should not compete, and current recommendations favours PN (7,14).

Challenges continue to remain to reduce morbidity from over-treatment of low-risk patients, as well as providing intensive treatment for high-risk patients (17). A review of 1,774 patients from SIOP 9301 with unilateral WT evaluated clinical factors and how it influenced the rate of intra-operative tumour rupture and incomplete resection. Unfavourable events were registered in 8% of the patients, and were statistically more likely in right-sided tumours, larger tumour volume at surgery and an older patient. The influence on 5-year event-free survival did not reach significance, which could be explained by effective adjuvant therapy. The overall survival rate, however, was significantly lower. A proposed reason for this is less therapeutic options in cases of relapse after a more intensive primary treatment (14).

The growing interest in MIS for renal tumours cannot be denied and the increasing numbers of publications prove that the strategy needs further assessment. Additional studies comparing MIS to open surgery in renal tumours in children are required, preferably randomized clinical trials or controlled clinical trials. Randomization of patients however, may prove to be difficult. Collaboration between specialized centres is needed to accomplish this. Challenges exist in the rarity of these tumours, the multimodal approach and differences between protocols. Study protocols are in the process of being renewed and these will implement the role of MIS in renal tumours, and define recommendations

concerning indications and contra-indications. The surgical panel in the SIOP RTSG has planned to develop guidelines for MIS in nephroblastoma in the upcoming new treatment protocol. The aim is for prospective data acquisition and evaluation to be undertaken for the next trial based on these guidelines (7).

Another important question that will need to be addressed is where these procedures should be performed. With the emphasis on a high level of surgical experience in both oncology and laparoscopy, only high-volume centres with surgeons sub-specialized in the field of MIS may be able to offer the treatment. Close collaboration between every centre involved in the management of renal tumours in children would be needed in order to select patients with tumours amenable to NSS and MIS.

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Footnote

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