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Minimally invasive surgery for abdominal and thoracic neuroblastic tumors: A systematic review by the APSA Cancer committee

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ABSTRACT

Background: Minimally invasive surgery has broad applicability to pediatric diseases, including pediatric cancer resection. Neuroblastic tumors of childhood are highly variable in presentation, and so careful selection of appropriate candidates for minimally invasive resection is paramount to achieving safe and durable surgical and oncological outcomes.
Methods: The American Pediatric Surgical Association Cancer Committee developed questions seeking to better define the role of minimally invasive surgery for neuroblastic tumors. A search using PubMed, Medline, Embase, Web of Science, ProQuest Dissertations, and Clinical Trials was performed for articles published from 1998 to 2018 in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) guidelines.
Results: The evidence identified is all retrospective in nature. Minimally invasive surgical resection of neuroblastic tumors is safe for carefully selected smaller (4-6 cm) image defined risk factor (IDRF)-negative abdominal tumors when oncologic principles are followed. Size is a less-well defined criterion for thoracic neuroblastic tumors. Open approaches for both abdominal and thoracic tumors may be preferable in the presence of IDRF's.
Conclusion: Small tumors without IDRF's are reasonable candidates for minimally invasive resection. Surgical oncologic guidelines should be closely followed. The quality of data supporting this systematic review is poor and highlights the need for refinement in the study of such surgical techniques to improve knowledge and outcomes for patients with neuroblastic tumors.
Type of Study: Systematic Review.
Level of Evidence: Level III and Level IV.

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Surgical management of neuroblastic tumors has historically been performed via open techniques. Advances in surgical technology have made available safe and reproducible minimally invasive approaches which have potential advantages over open surgery, including decreased post-operative length of stay, decreased post-operative pain, and improved cosmesis [1–3]. However, there are critical elements to every operation that must be performed regardless of approach. This is particularly important for pediatric neuroblastic tumor resection, as subsequent therapy of certain tumor risk groups is linked to the completeness of surgical resection. The aim of this systematic review is to examine the data regarding indications, contraindications, and comparative outcomes of minimally invasive surgery for definitive resection of abdominal and thoracic neuroblastic tumors in pediatric patients.

1. Methods

1.1. Research questions

Members of the American Pediatric Surgical Association (APSA) Cancer Committee developed and refined the following questions to better define the role of minimally invasive surgery (MIS) for neuroblastic tumors: 1. When is MIS applicable to resection of abdominal neuroblastic tumors? 2. When is MIS applicable to resection of thoracic neuroblastic tumors? 3. What are the advantages of MIS surgical resection over open techniques? 4. What are the complications of MIS surgical resection of neuroblastic tumors and how do they compare with standard open techniques?

1.2. Search strategy

This systematic review was performed with the assistance of a medical librarian in accordance with the guidelines from the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) [4]. The search focused on minimally invasive surgery for neuroblastic tumors of all types in children and young adults. The MeSH headings “Neuroblastoma” and the subheading “surgery” as well as the MeSH terms “Laparoscopy” and “Thoracoscopy” were used. The search also included the MeSH heading “Neoplasm Recurrence, Local” and the subheading “epidemiology” along with natural language to obtain a broad yet targeted dataset. Published articles, dissertations, and gray literature (research produced by organizations outside of traditional academic publishing channels such as white papers, governmental agency reports, literature from private companies or consultants, etc.) were searched using Medline (Ovid), Embase (Elsevier), Web of Science (Thomas Reuters), ProQuest Dissertations, and Clinical Trials from 1998 to 2018. The limiters were “humans”, “all child” and “young adult”, and “last 20 years”. The resulting abstracts were reviewed for relevancy and then the associated manuscripts were reviewed by 3 of the authors for inclusion in this review. An independent review of the Ovid and PubMed databases was performed to identify any articles not captured by the above initial search strategy. The searches were followed with manual review of the references and abstracts of included studies, and full manuscript review of agreed upon studies by two of the authors.

1.3. Study selection

Inclusion criteria for this systematic review were manuscripts focused on a minimally invasive approach to resection of neuroblastic tumors. Exclusion criteria were non-oncologic indication for surgery, open only techniques, and patient age > 21 years old. All abstracts that were identified in the search strategy were exported into Rayyan for de-duplication and uploaded for screening [5]. Three members of the review team (JA, TH, MM) performed manual reviews of the identified abstracts. If no consensus was reached on an abstract, it was excluded. Full text review was performed by two of the authors (JG, JA).

1.4. Data extraction and analysis

The study characteristics and data points extracted from each study include specific operative details, including operative technique, open versus laparoscopic or thoracoscopic, use of preoperative imaging including image-defined risk factors (IDRF's), estimated blood loss, operative time, completeness of resection, and recurrence. Also included were the number of patients with neuroblastic tumors in each study, patient age, tumor size/dimensions, chemotherapy administration, tumor histology, tumor stage, postoperative complications, length of stay, overall, and event-free survival. These data were extracted, verified, and analyzed by the authors. Relevant data from included studies when available is summarized in Appendix 1.

2. Results

2.1. Search outcomes

The initial database searches identified 136 published articles. A manual review of references identified 22 duplicate studies that were eliminated. Of these 114 studies, 81 were eliminated during abstract review based on the defined exclusion criteria described earlier. Four additional studies were identified during independent secondary review to ensure that all relevant articles had been captured. These 4 and the remaining 33 studies serve as the basis for the systematic review describing the use of a minimally invasive approach for the surgical management of neuroblastic tumors.

2.2. Study characteristics

Thirty-seven studies were identified that discussed utilizing minimally invasive techniques for definitive resection of neuroblastic tumors. Twenty-one studies discussed laparoscopic tumor resections, 10 studies discussed thoracoscopic tumor resections and 6 discussed both. All 37 studies included were retrospective reviews. There are currently no published prospective studies supporting the use of MIS for neuroblastoma in children and data presented in this review is extracted from Level III and some Level IV evidence-based reports, Grade C recommendation.

2.3. Feasibility and safety of laparoscopy for abdominal neuroblastic tumors

Twenty-one studies including 396 patients were reviewed to evaluate the laparoscopic approach for definitive resection of abdominal neuroblastic tumors.

Fascetti-Leon reported a European multi-center survey of 68 infants and children with adrenal masses, of which 36 were neuroblastic histology [6]. In this review, MIS resection of adrenal masses was noted to be safe, with a low rate of complications (10.5%) in centers experienced in laparoscopy [6]. Complications described in this report included 5 patients with blood loss requiring transfusion, 1 tumor rupture, and 1 diaphragmatic injury repaired primarily. There were no conversions to open in this study.

Chan described a single center series of 38 pediatric patients with solid tumors approached with MIS over a 10-year period, including 3 neuroblastic tumors [7]. This series reported no complications associated with the neuroblastic tumor resection, no conversions to open, and concluded that MIS for carefully selected pediatric neuroblastic tumors is safe and acceptable [7].

In a feasibility and safety analysis by Al-Shanafey, laparoscopic adrenalectomy for neuroblastic tumors was performed in 18 patients [8]. Two required conversion to open procedure, one for hepatomegaly and poor visualization, and one for renal vessel encasement. No perioperative complications were reported in this study. Three patients developed local recurrence, all with stage IV disease. Median postoperative hospital stay was 2 days.

Nerli recently reported an acceptable feasibility and safety profile in a series of 18 patients that included both benign and malignant adrenal tumors (10 neuroblastic), including no intraoperative transfusions, no intraoperative tumor rupture, timely (<12 h) resumption of enteral nutrition, and an average length of stay of 50 h [9]. Of note, the 10 patients with neuroblastoma in this study had lower stage disease, 6 with stage 1 disease and 4 with stage 2B disease with a mean size of 7 cm [9]. No disease recurrence, including no port site recurrence at follow up ranging from 6 months to 6 years was reported in this heterogenous group.

De Lagausie evaluated the feasibility of MIS in a series of 9 patients with small (<6 cm) primary adrenal lesions (Stage 1 neuroblastoma ($n = 4$), Stage IV neuroblastoma ($n = 3$), unspecified suprarenal calcified lesions ($n = 2$)) and concluded that this approach is safe and feasible in select children with smaller (<6 cm) well-circumscribed lesions. This series reported a single local recurrence in a patient with stage IV disease with vascular adherence requiring conversion to laparotomy [2].

Acker demonstrated non-inferiority of MIS compared to open approaches in a single center study that included of 13 patients with neuroblastic tumors who underwent either biopsy ($n = 5$) or resection ($n = 8$), and reported no difference in the MIS vs open groups regarding intensive care unit admission (13% vs 26%, $p = 0.18$) and overall length hospital of stay (4.5 days vs 6 days, $p = 0.19$) [1]. Infectious complications were less common in the MIS group but did not meet statistical significance ($p = 0.09$). Two conversions to open laparotomy were reported in order to avoid bleeding complications. There were no port or surgical site recurrences in this study [1].

Skarsgard advocated for a MIS approach for carefully selected adrenal lesions including 9 patients with neuroblastic tumors (size 3.5 cm–4.6 cm), in which they report no complications, no conversions to open (in the neuroblastic cohort), no blood transfusion requirements, and a median LOS of 1.5 days (range 1–4.5 days) [10].

Saad studied a small series of 6 patients with neuroblastoma and ganglioneuroblastoma diagnoses (5 patients stage IV and 1 patient stage I) and concluded that MIS is a safe treatment option for neuroblastic tumors even in select patients with tumors greater than 2 cm, and demonstrated excellent DFS of 100% over a follow up time period of 6–48 months for these carefully chosen patients [11].

Kelleher reported equivalent recurrence and survival rates in patients with low and intermediate risk neuroblastic tumors as well as carefully selected high risk tumors undergoing an MIS approach for resection when compared retrospectively to an open resection cohort [12]. This group reported 2 conversions to an open procedure (1/11 low/intermediate risk group, 1/7 high risk group) for adherence to adjacent structures precluding safe resection. Fewer blood transfusions were reported in the MIS group compared to the open group (2/13 [26%] vs 18/48 [37%], $p < 0.05$). Selection criteria for a MIS approach in this report included size <5 cm and absence of vascular encasement, irrespective of risk group classification [12].

2.3.1. Conversion to open

In the studies reviewed, 12 reported on conversion to an open procedure and included 17 patients. Technical reasons identified for conversion to an open procedure include intraoperative bleeding, inadequate visualization of vital structures, inability to achieve a complete resection in accordance with sound surgical oncologic standards, although many studies did not state the reason for conversion.

2.3.2. Port site recurrence

Port site recurrence was not reported to occur following minimally invasive surgical resection of abdominal neuroblastoma in any of the studies reviewed.

2.3.2.1. Summary. MIS is feasible and can be safely performed for carefully selected abdominal neuroblastic tumors with acceptable morbidity based upon retrospective data. Reported complications in the studies reviewed included the need for blood transfusion in 7 patients, conversion to open procedures in 17 patients, ipsilateral renal atrophy in 2 patients, partial renal infarction in 2 patients, 2 diaphragm injuries, and 1 postoperative bowel obstruction. Conclusions cannot be drawn regarding disease-free or overall survival outcomes from these limited small and pathologically heterogeneous retrospective series.

2.3.3. The role of image-defined risk factors and surgical decision making

No randomized controlled study directly compared a MIS approach with open approach when accounting for IDRF's. The studies discussed below support the utilization of IDRF's for surgical decision making for abdominal neuroblastic tumors. While the completeness of surgical resection and impact on outcomes for children with neuroblastic tumors is not the primary focus of this study, the reports included need to be

interpreted with the recognition of the beneficial impact that the extent of primary tumor resection has on local progression and survival, as reported by von Allmen and colleagues from the Children's Oncology Group A3973 study of patients with high risk neuroblastoma [13], and Fischer and colleagues from the German neuroblastoma trial NB97 [14]. However, the goals of resection for neuroblastic tumors varies among the different risk groups, and for select patients with localized disease, safe observation is acceptable [15,16]. In the presence of IDRF's, the ability to achieve appropriate resection is more of a technical challenge, and therefore the experience level of the surgeon with MIS may drive the decision for approach to such tumors.

Leclair described a carefully selected series of 45 patients with adrenal and retroperitoneal neuroblastoma and described contraindications for primary MIS resection, including tumors crossing midline, the presence of IDRF's, and predictable risk of macroscopically incomplete resection due to size or location of the mass [17]. Using these guidelines, the authors achieved complete macroscopic resection in 96% of patients in this cohort and highlighted the role of an MIS approach for well-encapsulated adrenal lesions without IDRF's [17].

Irtan published a series of 19 patients with abdominal neuroblastic tumors of whom 8 had IDRF preoperatively (9 with IDRF at diagnosis). [3] MIS was performed in this cohort despite the presence of IDRF's, with complete macroscopic resection achieved in all but 1 patient. While no patient required conversion to an open procedure, one patient developed ipsilateral renal atrophy requiring subsequent nephrectomy. With these results, the authors of this study do not currently recommend MIS for tumors with IDRF's in the absence of larger study [3].

Mattioli described an objective measure to support contraindications to MIS based on the presence of IDRF's [18]. In this report of 21 patients, MIS for resection was only performed for tumors without IDRF's, whether at diagnosis or following neoadjuvant chemotherapy. In this carefully selected group of patients, no complications, specifically no blood transfusions, no conversion to open, and no port site or peritoneal metastases, were reported [15].

Similarly, Tanaka described contraindications for MIS resection of neuroblastoma based upon IDRF's and proposed that IDRF-negative tumors represent reasonable indications for a MIS approach for abdominal neuroblastoma [19]. In this study of 20 patients with neuroblastoma, the complication rate was significantly higher in IDRF-positive patients compared to IDRF-negative patients (80% vs. 0%, $p = 0.001$). Two patients were converted to an open procedure, and partial renal infarction occurred in 2 patients, all of whom had the presence of IDRF's at diagnosis. Others have also found that the presence of IDRF's is correlated with a greater risk of intraoperative bleeding and a higher conversion rate when compared to an open procedure [6].

2.3.3.1. Summary. The absence of IDRFs appears to be a safe criterion for the utility of MIS for abdominal neuroblastoma. Complications and conversion to open procedures are more common in the presence of IDRF's, and for these patients open resection may be preferable.

2.3.4. The role of tumor size and surgical decision making

Of the 396 patients reviewed, tumor sizes for patients undergoing laparoscopic resection ranged from 0.6 cm to 7 cm. While tumor dimension has not been uniformly considered a predictive factor of MIS success in pediatric patients, most studies reviewed suggest that a size <5-7 cm is optimal.

Kelleher compared the outcomes of 61 children undergoing an open adrenalectomy to 18 children undergoing laparoscopic adrenalectomy for high, intermediate, and low risk neuroblastoma who met specific surgical selection criteria: tumor size less than 5 cm and the absence of vascular encasement [12]. Using these specific criteria, there were no conversions to open procedures, no blood transfusions in the MIS group, faster operative times (332 vs 180 min in the high-risk tumor group, and 252 vs 157 min in the low and intermediate risk groups; $p < 0.05$) and shorter postoperative length of stay (11.3 vs 4.4 days in the high-risk group, and 9.5 vs 2.5 days in the low and intermediate risk groups, $P < 0.05$).

Yao showed similar results with a retrospective series of 13 patients who underwent laparoscopic resection of tumors ranging from 1.98–6.0 cm (mean 3.7 cm) in size. They reported 2 complications requiring conversion to open procedure, including one patient with renal vessel involvement that was unable to be dissected laparoscopically, and one diaphragm injury. For this highly selected group of patients, there were no recurrences and a 5-year survival rate of 100%, however, no patient in this group had myc-N amplification, and only a single patient required adjuvant chemotherapy, highlighting the extreme selection for patients undergoing a MIS approach in this study [20].

Irtan suggests establishing a 4 cm size guideline for resection of abdominal neuroblastoma with MIS, however, this was based upon a small series which primarily included size less than 4 cm without a comparison group [3].

The recent International Pediatric Endosurgery Group (IPEG) report states that an absolute limitation to MIS based upon size criteria alone cannot be determined but should be evaluated individually based upon the size of the mass relative to the child. While this consensus group concluded that there are no absolute contraindications to MIS for neuroblastoma, relative contraindications to MIS were described including size greater than 6 cm, enlarged veins, and involved adjacent organs or vascular structures. A strong suggestion of 5 cm was provided according to review of the current literature and general consensus [21].

2.3.4.1. Summary. The best evidence for optimal tumor size for laparoscopic excision of neuroblastoma and other neuroblastic tumors ranges from 4 cm to 6 cm without IDRF's in most reports and is supported by IPEG. However, this recommendation is based upon small, retrospective reports without true statistical comparative groups, and requires further study for validation.

2.3.5. Surgical factors

The well-recognized benefits of minimally invasive surgical techniques including shorter duration of surgery (172 min vs 221 min), earlier time to feeding (31 h vs 76 h), shorter postoperative length of stay (5.3 days vs 10.5 days), and quicker start of chemotherapy when biopsy only was performed (3.7 days vs 11.2 days) have been observed in patients who undergo laparoscopic primary resection of neuroblastic tumors, although comparative data is suboptimal and largely based upon single-institutional retrospective information [12,22,23]. In addition, the advantages reported likely relate to the lower surgical risks associated with resecting smaller localized tumors without IDRF's and less advanced tumors in most of these studies. Furthermore, the use of enhanced recovery after surgery (ERAS) protocols was not mentioned in the studies reviewed, but a growing recognition of the advantages of such care plans may contribute in the future to quicker recovery for both MIS and open approaches.

Iwanaka compared children who underwent a MIS approach ($n = 5$) to an open approach ($n = 24$) for resection of abdominal neuroblastoma, and corroborated existing evidence discussed previously that MIS for localized neuroblastoma allows for earlier feeding (31 h vs 76 h, $p < 0.05$) and decreased length of stay (5.3 days vs 10.5 days, $p < 0.05$) without increasing operating time (100 min vs 112 min, $p = NS$) and with comparable blood loss (12 ml vs 43 ml, $p = NS$) [22].

Likewise, Shirota further confirms this through a recent report that compared 9 patients undergoing laparotomy and 7 undergoing laparoscopy for the resection of neuroblastoma, all without IDRF's, and found notable advantages of laparoscopy including comparable operative times (172 min laparoscopy group vs 221 min laparotomy group, $p = NS$), faster resolution of ileus (3 days vs 4 days, $p = 0.023$), and less operative blood loss (5 ml/kg vs 2.1 ml/kg, $P = 0.037$). There were no significant differences in this cohort in locoregional recurrence rates, progression-free survival, or overall survival between the two groups. [23].

2.3.5.1. Summary. In a highly selected group of patients with small tumors and no IDRF's, potential advantages of minimally invasive approaches for resection of abdominal neuroblastic tumors are consistent with other MIS procedures, and include comparable blood loss, earlier time to feeding, and shorter length of stay.

2.4. Role of thoracoscopy for neuroblastoma

There were 155 patients included in this review who underwent thoracoscopy for the resection of thoracic neuroblastic tumors. Many studies included thoracoscopic resection of neuroblastic tumors as well as additional histologic tumor types, and so attempts to include only neuroblastic tumors for the purposes of this review were made. For children with thoracic neuroblastoma, 11 studies described thoracoscopic incisional biopsy for advanced disease and 12 studies which comprised the 155 patients described a thoracoscopic approach for complete resection. Six studies commented on achieving acceptable gross total or near total resection for neuroblastoma involving the neural foraminal space. Ten studies described the technique used for thoracoscopic resection using 3–4 ports, minimal to no CO2 insufflation, single lung ventilation and use of an endoscopic bag for tumor retrieval. Two studies commented on lymph node sampling when clinically indicated. It should be noted that thoracic neuroblastic tumors generally have improved outcomes overall compared to abdominal sites, presenting more commonly as lower-stage or favorable disease when compared to other locations. These findings are consistent throughout the studies reviewed.

2.4.1. Feasibility and safety of thoracoscopy for thoracic neuroblastic tumors

Thoracic neuroblastic tumors have been traditionally approached via a posterolateral thoracotomy. However, a less invasive approach is advantageous whenever possible given the association of thoracotomy with scoliosis or other chest wall deformities in up to 30% of children [24–27]. Recently, MIS approaches for resection of thoracic neuroblastic tumors have become more appealing, preserving oncological standards with safe resection [24,28].

A large multicenter series from Japan by Asabe evaluated 256 thoracoscopic procedures performed for varying diagnoses in infants and children including 11 thoracoscopic resections of neuroblastoma. No perioperative complications were reported in this small subgroup of patients undergoing tumor excision.

Fraga published a retrospective series of 17 patients with thoracic neuroblastic tumors, showing that thoracoscopy is feasible (no conversions to open thoracotomy), safe (2 cases of postoperative Horner's syndrome, which was anticipated based upon tumor location), and effective (no recurrences at a median follow up of 16 months) for the removal of thoracic neuroblastic tumors in children [29].

Another recent study performed in France by Lacreuse evaluated the resection of 21 low risk neuroblastic tumors via thoracoscopy [24]. The authors demonstrated that the technique is safe and allowed for necessary mobilization and complete resection of thoracic neuroblastoma in all except one patient who required conversion to thoracotomy due to large size of the tumor. A single chyle leak was reported, and 4 cases of postoperative Horner's syndrome were recorded but not likely avoidable or attributed to the MIS approach.

Partrick described the successful feasibility of thoracoscopic resection in 38 of 39 tumors, of which 6 were neuroblastic [30]. No intraoperative complications occurred, although 1 child received a postoperative blood transfusion.

Guye reported a multicenter study that included both neuroblastic and other histologies, concluding that thoracoscopy is a safe and effective approach for thoracic tumors [31]. Complications reported in this study included 1 case of chylothorax that resolved with conservative management, and 1 case of Horner's syndrome that resolved within 1 year.

A direct comparison between thoracoscopy and thoracotomy for the resection of neuroblastic tumors was performed in 2 studies retrospectively [32,33]. Malek reported 26 open thoracotomy patients and 11 thoracoscopic patients with no differences in demographics, tumor size, or presurgical therapy between the groups [32].Estimated blood loss was lower in the thoracoscopic group (median 10 ml vs 25 ml, $p = 0.02$), and length of stay was shorter in the thoracoscopic group (2 days vs 3.5 days, $p = 0.01$). No difference in length of operation (150 min vs 181 min, $p = 0.41$) or in postoperative complications (27% vs 20%, $p = 0.68$) were noted between the two groups. Similarly, Petty retrospectively compared 17 children, 10 MIS and 7 open thoracotomy for resection of neuroblastic tumors [33]. No statistically significant differences were found between the groups regarding tumor size, operative times, or blood loss. Hospital stay was significantly shorter in the MIS group (mean 1.9 days vs 4.1 days, $p < 0.05$), and complications were similar between techniques (Horner's syndrome in 2 MIS, 3 open patients) [33].

2.4.2. Conversion to open

From all patients reviewed who underwent resection, ($n = 155$), 20 thoracoscopies required conversion to open thoracotomy for reasons including: 9 related to surgeon preference following intraoperative confirmation of diagnosis, 7 due to size of the tumor, 2 due to proximity to vital structures, 1 secondary to bleeding, and 1 related to poor visualization from inadequate lung ventilation.

2.4.3. Port site recurrence

Port site recurrence was not reported to occur following minimally invasive resection of thoracic neuroblastoma in any of the studies reviewed.

2.4.3.1. Summary. Thoracoscopic approach to the resection of thoracic neuroblastic tumors seems feasible, safe, and effective. Although no study prospectively compared open thoracotomy with thoracoscopy, the complications reported with a MIS approach are few and comparable to thoracotomy based upon retrospective comparison.

2.4.4. Role of IDRF's and surgical decision making

Similar to abdominal primary tumors, thoracic neuroblastic tumors may be more amenable to MIS resection in the absence of IDRF's. However, only a single study mentions utilizing IDRF's for surgical planning of thoracic neuroblastic tumors [3]. The authors of this study highlight the value of IDRFs in providing objective criteria to define the surgical risk and resectability of thoracic neuroblastic tumors. This series reported 3 chyle leaks which all occurred in IDRF-positive tumors.

2.4.4.1. Summary. Only 1 study identified discussed the use of IDRF's in providing objective criteria for surgical planning for thoracic neuroblastic tumors.

2.4.5. Tumor size and surgical decision making

The size of the primary tumor as a criterion for MIS resection of thoracic neuroblastic tumors has not been as extensively studied as tumors in intraabdominal/retroperitoneal locations. Six studies commented on size as a criterion for MIS approach to thoracic neuroblastic tumors [3,24,29,31–33]. Tumor size in these studies ranged between 2 cm and 18 cm, although most commonly reported sizes were between 3 and 5 cm. Size was cited as a conversion reason in 7 patients.

2.4.5.1. Summary. Size criterion is not well-defined for eligibility of a minimally invasive approach for the resection of thoracic neuroblastic tumors.

2.4.6. Surgical factors

Of the 155 patients undergoing thoracoscopy for resection who were included in these reports, complications included 20 conversions to

open thoracotomy, 14 patients with postoperative Horner's syndrome, 7 with chylothorax, 2 with intraoperative bleeding, 1 with a postoperative pneumothorax requiring tube thoracostomy, and 1 pleural effusion.

2.4.6.1. Summary. Comparable rates of complications following thoracoscopic resection of neuroblastic tumors have been reported when compared to an open approach and are likely more attributable to tumor location rather than method of resection. Tumors undergoing MIS resection in the reported studies were highly selected which may explain improved morbidity when compared to open thoracotomy.

3. Discussion

The purpose of this systematic review is to provide evidence to guide MIS approaches for the surgical management of abdominal and thoracic neuroblastic tumors. There are no prospective studies comparing MIS to open approaches for the resection of neuroblastic tumors, and the feasibility of such a study in the future is unlikely given the heterogenous and complex nature of these tumors. Although the retrospective nature of and heterogenous data provided in all studies identified in this review limits the strength of recommendations, the relative indications, contraindications, outcomes and most common complications for both laparoscopy and thoracoscopy can be defined. It must be emphasized that the application of MIS techniques on inappropriate patients or by surgeons with limited MIS skills could impart significant morbidity to these patients. Additionally, due to selection bias in choosing an optimal surgical approach as well as the broad inclusion of both benign and malignant neuroblastic tumors of varying stages and current cooperative group risk categories in the studies reviewed, oncologic outcomes are not possible to compare between techniques from these data. Specifically, the purpose of this study was not to determine which method of surgical resection resulted in better survival, as the treatment of neuroblastic tumors is multifactorial. The principles of surgical resection including completeness of resection may vary dependent upon risk group stratification within neuroblastic tumors and therefore may influence decisions on surgical approach. In addition, there are important biologic factors that are of equal or more importance than resection alone. A thorough understanding of the goals of surgery and impact on outcomes for variable risk neuroblastic tumors is critical when considering the use of MIS. While the completeness of surgical resection for high risk neuroblastic tumors has demonstrated a lower cumulative incidence of local failure, the surgical impact is less clear on overall outcomes and survival [13,14,34–36], and has no bearing on risk stratification in the current classification system [37]. Furthermore, despite the surgical temptation to resect low-risk localized tumors via an MIS approach, certain risk groups require no resection but may be safely observed thereby eliminating surgical morbidity altogether [15,16].

Table 1
IPEG guidelines for the surgical management of adrenal masses in children. [18].

For advanced neuroblastoma, open resection recommended, laparoscopic biopsy may be performed
Laparoscopic resection considered for small neuroblastic tumors without invasion
- Size <6 cm
- Lack of enlarged veins or other vessel invasion
- Lack of invasion of adjacent organs
Extract tumor using endobag
Laparoscopy appropriate for pheochromocytomas, adrenal hyperplasia, and benign adrenal lesions

IPEG, International Pediatric Endosurgery Group.

Patients should be highly selected for MIS approaches to resection of neuroblastic tumors, primarily based upon size and the presence of IDRF's. Recently, The International Pediatric Endosurgery Group (IPEG) published guidelines (class III evidence) for the surgical management of adrenal masses in children (Table 1) [21]. These guidelines state that laparoscopic adrenalectomy and adrenal biopsy are technically feasible in children. For advanced neuroblastoma, this consensus suggested that laparoscopic biopsy may be performed, and that laparoscopic resection of small localized tumors may be performed as long as the principles of oncologic surgery are maintained. MIS can also be considered for higher risk disease if the tumor responds favorably to neoadjuvant chemotherapy. In the presence of virilization, Cushing syndrome, or other suspicions for adrenocortical carcinoma, a MIS approach for resection is discouraged. A strong recommendation was made by this group to remove all tumors using an endoscopic retrieval bag.

The evidence presented in this systematic review demonstrates that MIS is a safe approach for select smaller IDRF-negative abdominal and thoracic neuroblastic tumors when oncologic principles are followed by experienced surgeons. The indications and contraindications for MIS resection of abdominal and thoracic neuroblastic tumors have been summarized while highlighting the relatively low and comparable complication rate to open procedures. As evidenced in this review, a preoperative objective assessment by IDRF's and size criteria is recommended to guide approaches in order that oncologic principles of surgical resection of neuroblastic tumors are followed with the least possible morbidity. However, the ultimate outcome for malignant neuroblastic tumors based upon method of surgical resection alone is unknown.

This review also reveals the existing poor quality of data guiding pediatric surgical oncology methods and highlights the need for refinement in the study of these surgical techniques to further optimize care and decrease morbidity for children with neuroblastic tumors.

Appendix 1
Summary of included studies describing minimally invasive approaches to abdominal and thoracic neuroblastic tumors.

Source	No. of Patients	Average Age	Histology	Preop. Chemo (n)	EBL (mL)	OR Time, Mean (min., range)	Average Tumor Volume (cc, range) [Largest dimension if vol. not available]	No. of Lymph Nodes	Gross Intra-op Rupture (%)	Average LOS (d, range)
Laparoscopy										
De Lagausie	9	Mean = 3.1 yr. (2mo. –9 yr.)	Poorly differentiated neuroblastoma (4) Ganglioneuroblastoma (5)	3	100	85 (45–170)	Largest dimension, avg. (cm): 6, (2.2–6)	Median = 2 (1–2)	0	4.5 (2–10)
Sukumar	7	Mean = 9.6 yr	Neuroblastoma (1) Normal adrenal (1) Adrenal hyperplasia (2) Pheochromocytoma (2) Ganglioneuroma (1)	NR	50	111 unilateral 263 bilateral	Largest dimension, avg. (cm): 4.8, (2–7)	NR	0	5.3 (3–10)
Skarsgard	9	6.4 yr. (14mo-18 yr)	Neuroblastoma (5) Ganglioneuroma (4) Adrenocortical carcinoma (1) Pheochromocytoma (1) Benign adrenal lesion (10)	NR	NR	101 +/−48	4.6 cm (3–8.5 cm)	NR		
Nerli	18	Mean = 5.8 yr. (14mo. – 15 yr.)	Neuroblastoma (10) Adrenal hyperplasia (2) Virilising tumor (3) Pheochromocytoma (2) Adrenal cyst (1)	NR	30	95 (75–145)	NR	NR	0	2 (1.5–3)
Saad	6	Mean = 2.2 yr. (7mo-5 yr)	Neuroblastoma (2) Ganglioneuroblastoma(4)	NR	NR	149 (85–190)	Largest dimension, avg. (cm): 3.7, (2–4)	NR	0	1.2 (1–2)
Leclair	45	Median = 6.8 mo (0–9.5 yr	Neuroblastoma (45)	18	NR	85 (50–190)	Volume: 11 cm^3 (1–88) Largest dimension, avg. (cm): 3.7 (12–70)	NR	1	3 (2–8)
Mattioli	21	Median = 14 mo (1mo-10 yr)	Neuroblastoma poorly differentiated (21)	9	NR	90 (50–210)	Largest dimension, avg. (cm): 3 (1–8.3)	NR	0	4 (2–10)
Tanaka	20	Median = 11 mo (0–71)	Neuroblastoma	9	IDRF-negative = 6 IDRF-positive = 40	IDRF-negative = 143 IDRF-positive = 307	Largest dimension, avg. (cm): 3.8 (20–55)	NR (performed in high risk patients)	0	IDRF-negative = 6 IDRF-positive = 6
Fascetti-Leon	68	Mean = 5.2 yr. (2mo-16 yr)	Neuroblastoma (36) Adenomas (15) Pheochromocytomas (9) Ganglioneuromas (3) Ganglioneuroblastoma (2) Bilateral Hyperplasia (1) Adrenocortical Carcinoma (1) Alveolar Sarcoma (1) Benign Calcification (1)	Neuroblastomas only 15	NR	170 (83–257)	Volume: 18.1 cm^3 (0.78–145), largest diameter 6.5 (1.1–6.5) mean 2.8	NR	0	4.2 (1.7–6.7)
Shirota	9	Median = 28 mo (IQR 21–51)	Neuroblastoma (9)	5	Mean = 2 ml/kg	172 (122–253)	Largest dimension, avg. (cm): 4.3 (2.6–4.8)	NR	1 (IDRF +)	NR
**Romano Level II not randomized*	26	Mean = 50 mo (1mo-14 yr)	Neuroblastoma (21) Pheochromocytoma (6) Hyperplasia (1)	NR	NR	90	Largest dimension, 2–30	NR	NR	NR
Kelleher	18	Mean= High risk 41 mo Low/intermediate risk 17 mo	Neuroblastoma	NR	NR	HR – 180 L/I – 157	Largest dimension, High risk 2.9 (0.9–4.3) Low/intermediate 2.4 (1.7–2.9)	0	NR	HR – 4.4 L/I – 2.5
Iwanaka (2007)	6	Mean = 18.7mo (9.2–28.2)	Neuroblastoma	NR	6 (4–8)	113 (97–129)	NR	NR	NR	7.3 (6–8.6)
Iwanaka (2001)	11	Median = 28mo (4mo-13 yr)	Neuroblastoma	NR	12 (2–22)	100 (90–110)	NR	Sampled when necessary	NR	5.3 (4.7–5.9)
Hubertus	11	Median = 4mo	Neuroblastoma (9)	NR	NR	98 (45–105)	<6 cm	NR	NR	6 (1–90)

		(1–16)	Adenoma (1) Necrosis (1)							
Yao	13	Mean 37.2 +/−38 mo	Neuroblastoma	1	13.9 ml (+/−12.4)	143.9 +/−48.4	3.77 cm +/−1.35	NR	NR	NR
Al-Shanefey	29	Median 3 yrs. (3 weeks – 13 yrs)	Neuroblastoma (16) Adrenocortical carcinoma (5) Pheochromocytoma (2) Ganglioneuroma (2) Benign lesions (4)	NR	NR	Median 144 min (100–330)	2.8-7 cm	NR	NR	Median 2 (2–4)
Thoracoscopy										
Malek	11	Median = 13mo (8-156mo)	Neuroblastoma	3	10 (0–75)	150 (53–468)	NR	When necessary	NR	2 (1–7)
Fraga'12	17	Median = 16mo (10.6-60mo)	Neuroblastoma (10) Ganglioneuroma (4) Ganglioneuroblastoma (3)	2	NR	90 (45–180)	Largest dimension, avg. (cm): 5 (2–18)	NR	NR	3 (2–3)
Guye	139	Mean = 9.2 yr. (3–17)	Complete resection (20) Neuroblastoma (4) Ganglioneuroblastoma (2) Bronchio-alveolar carcinoma (1)Ganglioneuroma (11)Thymic Hyperplasia (2) Biopsy (9)	NR	NR	NR	Neuroblastoma 4 cm Ganglioneuroma 10 cm Bronchio AC (2)	NR	NR	NR
Asabe	256		Neuroblastoma (11) Mediastinal tumor (25)							
Lacreuse	21	NR	Neuroblastoma (9) Ganglioneuroblastoma (9) Ganglioneuroma (3)	0	NR	100	Largest dimension, avg. (cm): 6 (3–10)	NR	NR	(4–12)
Partrick	39	Mean 4.2 yr. (5mo-18 yr)	Foregut Duplication (12) Ganglioneuroma (7) Neuroblastoma (6) Lymphoma (6) Teratoma (3) Sarcoma (2) Thymoma (1) Pericardial cyst (1) Castleman's disease (1)	NR	NR	72 (20–185)	NR	NR	NR	2.2 (0.5–4)
Nio	6	3.5 (1.1–6.8 yr)	Ganglioneuroblastoma(2) Neuroblastoma (1) Ganglioneuroma (3)	NR	52 (14–150)	230 (138–310)	NR	NR	NR	7.6(7–11)
Fraga '10	43	44.8mo (12.9mo-67mo)	Neuroblastoma (20) Ganglioneuroblastoma (13) Ganglioneuroma (10)	20 Neuroblastoma (15) Ganglioneuroblastoma (5)	NR	Thoracoscopy cases 180 (132–190)	Largest dimension (thoracoscopy cases), avg. (cm): 2 (2–5.7)	NR	NR	Thoracoscopy = 4 (2.5–5) Thoracotomy = 6 (5–8.3)
Petty	10	5 yr. (0.5-12 yr)	Neuroblastoma (5) Ganglioneuroma (4) Malignant peripheral nerve sheath tumor (1)	1	24	114 (62–166)	Largest dimension, avg. (cm): 5.2 (3–8.5)	NR	NR	Thoracoscopy = 1.9 (1.2–2.6) Thoracotomy = 4.1 (1.6–6.6)
Mixed										
Chan	38	Mean 7.5 yrs (1d-15 yr)	Ovarian (22) Sacrococcygeal (4) Adrenal (3) Retroperitoneum (3) **Neuroblastoma (2)** Kidney (1) Liver (1)	NR	NR	171 (45–275)	NR	NR	NR	NR

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Appendix 1 *(continued)*

Source	No. of Patients	Average Age	Histology	Preop. Chemo (n)	EBL (mL)	OR Time, Mean (min., range)	Average Tumor Volume (cc, range) [Largest dimension if vol. not available]	No. of Lymph Nodes	Gross Intra-op Rupture (%)	Average LOS (d, range)
			intra-abdominal testicular teratoma (1) Thorax (3)CCAM (1) **Neuroblastoma (1)**							
Acker	98	Mean 10.2ys (3.8–16.6)	Neuroblastoma (27) Hodgkin lymphoma (16) Ewing sarcoma (14)	NR	NR	165 (100–220)	NR	NR	NR	5.9
Irtan	39	Median 44.5mo (3.1-171mo)	Neuroblastoma (22) Ganglioneuroblastomas(11) Ganglioneuroma (6)	Thorax (6) Abdomen (4)	NR	130 (60–270)	Largest dimension, avg. (cm): Thorax 0.35 (0.7–8.5) Abdomen 3.4 (1–7.5)	NR	NR	5.2 (2–10)

Source	No. of Patients (n)	Complications (n)	DFS (%, follow-up time frame)	Histology	Stage (n)	Notes
Laparoscopy						
De Lagausie	9	1 conversion to open (adhesions) 1 port site infection	8/9 (88%, 15 mo) Local recurrence in patient with +IDRF that required conversion to laparotomy	Poorly differentiated neuroblastoma (4) Ganglioneuroblastoma (5)	Stage I (4) Stage IV (3) Undetermined (2)	2 tumors diagnosed prenatally Transperitoneal approach all cases N-myc amplified (2) 1 local recurrence (patient requiring laparotomy)
Sukumar	7	0	1/1 (100%,24 mo)	Neuroblastoma (1) Normal adrenal (1) Adrenal Hyperplasia (2) Pheochromocytoma (2) Ganglioneuroma (1)	Stage I (1)	Included pheochromocytoma, Cushing's disease adrenalectomy
Skarsgard	9	1 conversion to open 0 complications	100%	Neuroblastoma (5) Ganglioneuroma (4) Adrenocortical carcinoma (1) Pheochromocytoma (1) Benign adrenal lesion (10)	NR	
Nerli	18	0	10/10 (100%, 6 yr)	Neuroblastoma (10) Adrenal hyperplasia (2) Virilising tumor (3) Pheochromocytoma (2) Adrenal cyst (1)	Stage I (6) Stage IIB (4)	Included surgical adrenalectomy for benign disease
Pastor	7	1 conversion to open (bleeding)	5/7 (71%, 7 yr)	Neuroblastoma (7)	Stage II (1) Stage III (1) Stage IV (4)* Stage IVs (1)	*One patient with Stage IV had bilateral disease with staged approach. N-myc amplified (3) R2 resection (1) (patient requiring laparotomy) 1 patient deceased at 1 yr
Saad	6	0	6/6 (100%, 6–48 mo)	Neuroblastoma (2) Ganglioneuroblastoma(4)	Stage I (1) Stage IV (5)	1 patient stayed for 28 days due to start of chemotherapy.
Leclair	45	4 conversions to open 1 Post op small bowel obstruction 1 ipsilateral renal ischemia 1 urinary retention 1 SSI superficial	38/45 (84%, median 28 mo)	Neuroblastoma (45)	Stage I-III (28) Stage IV (11) Stage IVs (6)	Multicenter study. Included 7 institutions. N-myc amplified (5) R2 resection (2) Unresectable Stage III tumors (4), achieved complete resection after chemotherapy
Mattioli	21	1 intra op hemorrhage (did not require transfusion)	21/21 (100%, 60 mo)	Neuroblastoma poorly differentiated (21)	Stage I-III (12) Stage IV (9)	Image-defined risk factors dependent algorithm for therapy.
Tanaka	20	2 conversion to open (adhesions to IVC and renal vein) 2 ipsilateral side partial infarction of the kidney	17/20 (85%, 44mo)	Neuroblastoma	Stage I (8) Stage IIB (2) Stage III (2) Stage IV (6) Stage IVs (2)	Both patients who required conversion to open were IDRF-positive. No complications in IDRF-negative patients N-myc amplified (3)
Fascetti-Leon	68	5 patients required transfusion intraop.	66/68 (97%, 52mo, (1–161)	Neuroblastoma (36)	Neuroblastoma	6 European Centers Included benign masses

		1 diaphragmatic tear		Adenomas (15) Pheochromocytomas (9) Ganglioneuromas (3) Ganglioneuroblastoma (2) Bilateral Hyperplasia (1) Adrenocortical Carcinoma (1) Alveolar Sarcoma (1) Benign Calcification (1)	only Stage I (22) Stage III-IV (11) Stage IVs (3)	2 recurrences occurred in patients with pheochromocytoma.
Shirota	9	0	9/9 (100%, 21mo, (17–28))	Neuroblastoma (9)	NR	IDRF + (2) – 1 conversion to open IDRF – (7) – 2 cases converted from IDRF + to IDRF – after chemotherapy MYCN amplified (2)
Romano	26	1 Renal artery laceration 1 Diaphragmatic perforation	20/26 (76%)	Neuroblastoma (21) Pheochromocytoma (6) Hyperplasia (1)	Neuroblastoma only Stage I (9) Stage IIB (2) Stage III (3) Stage IV (6) Stage IVs (1)	MYCN amplified (3) 1p deletion (1) Study includes open procedures. Only 2 neuroblastomas were MIS stage I
Kelleher	18	2 conversions to open 1 dead HR patient with progressive pulmonary complications from metastatic disease	17 /18 (94%) HR – (19mo) L/I – (42mo)	Neuroblastoma	Median High risk IV Low/intermediate I	
Iwanaka (2007)	6	1 intraoperative bleeding requiring transfusion 1 conversion to open due to adhesions to renal vessels	Not evaluated	Neuroblastoma	Stage III (1) Stage IV (2)	Included biopsy cases for advanced neuroblastoma Reports no port-site recurrence (0)
Iwanaka (2001)	11	1 conversion to open due to bigger retroperitoneal mass found	NR	Neuroblastoma	Stage I-II (4) Stage III-IV (7)	6 biopsies for advanced disease 5 excisions.
Hubertus	11	1 colon perforation 2 incisional hernia	11/11 (100%, 7mo, (2–31)	Neuroblastoma (9) Adenoma (1) Necrosis (1)	Stage I-III (9) Stage IV (1)	MYCN amplified 0 1p deletion 0
Wei	13	2 conversion to open due to adhesions to renal vessels 1 diaphragmatic rupture	13/13 (100%, 86mo (62–110)	Neuroblastoma	NR	
Yao	13	1 conversion due to renal vessel involvement 1 conversion due to diaphragm injury	100%	Neuroblastoma	Stage I (12) Stage II (1)	
Al-Shanafey	29	1 conversion for enlarged liver 1 conversion for renal vessel encasement 1 conversion for hemodynamic instability	90%	Neuroblastoma (16) Adrenocortical carcinoma (5) Pheochromocytoma (2) Ganglioneuroma (2) Benign lesions (4)	Stage I (5) Stage IV (10) Stage IVs (5)	
Thoracoscopy						
Malek	11	2 Horner's syndrome 1 severe atelectasis	10/11 (90%)	Neuroblastoma	Stage I (4) Stage II (6) Stage IV (1)	MYCN amplified 2
Fraga'12	17	2 Horner's syndrome	17/17 (100%, 16mo (8.9–28.6))	Neuroblastoma (10) Ganglioneuroma (4) Ganglioneuroblastoma (3)	Stage I (4) Stage II (5) Stage III (3) Stage IVs (1)	Included ganglioneuroma
Guye	139	Of complete resections (20): 2 had chylothorax 1 Horner's syndrome Of Biopsy (9): All neuroblastoma converted to open	4.5 yr. (3mo-12 yr)	38 tumors Complete resection (20) Neuroblastoma (4) Ganglioneuroblastoma (2) Bronchio-alveolar carcinoma (1) Ganglioneuroma (11) Thymic Hyperplasia (2)	NR	Multicenter study for treatment of solid tumor and metastatic disease. No tumor recurrence at port sites (including metastasectomies)

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Appendix 1 *(continued)*

Source	No. of Patients (n)	Complications (n)	DFS (%, follow-up time frame)	Histology	Stage (n)	Notes
				Biopsy (9) All neuroblastoma converted to open		
Asabe	256	NR	NR	Pectus (121) Pneumothorax(25) Mediastinal tumor(25), hyperhidrosis(23) Neuroblastoma(11) Cystic lung (10)	NR	Review on thoracoscopy for all procedures involving children in japan
Lacreuse	21	1 conversion due to large mass 2 chylothorax 4 Horner's syndrome	21/21 (100%, 18mo-6.5 yr)	Neuroblastoma (9) Ganglioneuroblastoma (9) Ganglioneuroma (3)	Stage I (21)	All tumors removed with bag Complete resection in all cases. None needed adjuvant therapy (all stage I) Discusses SLV and mainstem intubation
Partrick	39	1 conversion due to extensive disease	39/30 (100%)	Foregut Duplication (12) Ganglioneuroma (7) Neuroblastoma (6) Lymphoma (6) Teratoma (3) Sarcoma (2) Thymoma (1) Pericardial cyst (1) Castleman's disease (1)	NR	Discusses SLV and mainstem intubation All tumors removed in bag Complete resection 33/39 Chest tube 8/39 Adjuvant chemo for lymphoma and sarcoma patients
Nio	6	0	6/6(100%, 12–76)	Ganglioneuroblastoma(2) Neuroblastoma (1) Ganglioneuroma (3)	Stage I (3)	Discusses SLV All tumors removed in bag Used selective bronchial blocker (Fogarty) Chest tube for all patients
Frage '10	43	Thoracoscopy 2 Horner's syndrome	Thoracoscopy 5/5 (100%, 23 mo)	Neuroblastoma (20) Ganglioneuroblastoma (13) Ganglioneuroma (10)	Stage I (7) Stage II (9) Stage III (8) Stage IV (6) Stage IVs (3)	All tumors removed in bag *Only 5 patients underwent Thoracoscopy Chest tube for all cases, median days (2)
Petty	10	2 Horner's syndrome 1 conversion due to difficulties with single lung ventilation.	8/10 (80%, 19 mo)	Neuroblastoma (5) Ganglioneuroma (4) Malignant peripheral nerve sheath tumor (1)	Stage I (2) Stage II (2) Stage III (0) Stage IV (1)	No port site recurrences.
Mixed						
Chan	38	Thoracoscopy (3) 1 conversion Laparoscopy 8 conversions to open 6 due to size 1 due to bleeding	NR	Ovarian (22) Sacrococcygeal (4) Adrenal (3) Retroperitoneum (3) **Neuroblastoma (2)** Kidney (1) Liver (1) intra-abdominal testicular teratoma (1) Thorax (3) CCAM (1) **Neuroblastoma (1)**	NR	All abdominal tumors removed in bags 35 abdominal 3 thoracic 30/35 complete MIS resection Neuroblastoma all resected MIS Comments on the use of MIS for sacrococcygeal teratomas
Acker	98	Thoracoscopy (78) 1 pneumothorax 1 pleural effusion 1 surgical specimen insufficient for diagnosis 3 laparoscopies converted to open 4 thoracoscopies converted to open	(89%, 2.5ys)	Neuroblastoma (27) Hodgkin lymphoma (16) Ewing sarcoma (14)	NR	No port site recurrences. 72% of thoracoscopies were for biopsies 9/14 (64%) neuroblastomas completely resected by thoracoscopy 6 /13 (46%) neuroblastomas completely resected by laparoscopy
Irtan	39	Thoracoscopy (20)	38/39 (97%, 25 mo)	Neuroblastoma (22)	INRGSS	MYCN + (1) (thoracic)

3 conversion to open (2 too close to aorta, 1 intercostal involvement)(thoracic) 1 Horner's syndrome (thoracic) 3 chylothorax (thoracic) 1 renal atrophy (abdominal)	Ganglioneuroblastomas(11) Ganglioneuroma (6)	Thorax L1 (5) L2 (5) M (7) Ms.(3) Abdomen L1 (9) L2 (7) M (3) Ms.(0)	All tumors removed in bag Thoracoscopy Chest tube mean 2.7 days IDFR – (20) 1 IDFR (18) 2 IDRF (2) IDFR disappeared in 2/8 receiving neoadjuvant chemotherapy

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