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Minimally Invasive Approaches In The Surgical Management Of Localized Neuroblastoma

Dr. Priyanka Dutta

Abstract
Neuroblastoma is one of the most common extracranial solid tumors in children, often requiring a multidisciplinary approach for management. While open surgery has traditionally been the mainstay for resecting localized tumors, minimally invasive surgery (MIS) has emerged as a viable option with favorable outcomes. This manuscript reviews current evidence, surgical techniques, safety profiles, and oncological outcomes of minimally invasive approaches for localized neuroblastoma.

Keywords: *Neuroblastoma, Minimally Invasive Surgery, Pediatric Oncology, Laparoscopic Resection, Thoracoscopic Surgery, Robotic-Assisted Surgery, Localized Neuroblastoma, Image Defined Risk Factors (IDRFs), Pediatric Surgical Oncology, Tumor Resection.*

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I. Introduction

Neuroblastoma accounts for approximately 8–10% of all pediatric cancers and is most frequently diagnosed before five years of age. Localized neuroblastomas (INRG stages L1 and selected L2) are potentially curable with surgical resection. Minimally invasive surgical (MIS) techniques, including laparoscopic and thoracoscopic approaches, are increasingly being adopted due to lower morbidity and faster recovery.

II. Pathophysiology And Surgical Indications

Neuroblastomas arise from neural crest cells of the sympathetic nervous system. Localized tumors often present as an abdominal mass without systemic symptoms. Indications for surgery include tumor resection following initial chemotherapy (if indicated), or upfront resection for low-risk tumors.

III. Minimally Invasive Techniques

Laparoscopic Resection: Used for adrenal and retroperitoneal neuroblastomas.
- Advantages: Reduced blood loss, less postoperative pain, faster recovery.
- Limitations: Difficulty in vascular control, especially with major vessel involvement.

Thoracoscopic Resection:
Ideal for posterior mediastinal tumors.
- Advantages: Better visualization, shorter hospital stay.
- Challenges: Risk of pneumothorax, vital structure injury.

Robotic-Assisted Approaches:
Still evolving in pediatrics; provides enhanced dexterity and 3D vision.
- Potential Benefits: Precise dissection near critical structures.
- Barriers: High cost, limited access, longer operative time.

IV. Preoperative Considerations

- Imaging: CT/MRI for tumor extent; MIBG scan for staging.
- IDRFs (Image Defined Risk Factors): Crucial in deciding MIS feasibility.
- Multidisciplinary Discussion: Essential in planning resection timing and method.

V. Oncological Outcomes

Studies suggest comparable outcomes between MIS and open surgery for L1 tumors.
- Complete resection rates: >90% in select MIS cases.
- Local recurrence: No significant increase reported with MIS.
- Survival rates: Similar to open procedures when IDRFs are absent.

VI. Intraoperative Safety And Complications

- Blood loss: Significantly lower in MIS.
- Complications: Vascular injury, tumor rupture, conversion to open surgery.
- Conversion rate: Approximately 10–15% in large series.

VII. Postoperative Recovery

- Hospital Stay: Shortened (average 3–5 days in MIS vs 7–10 in open).
- Analgesia Needs: Lower with MIS.
- Return to Normal Activity: Faster in MIS group.

VIII. Limitations And Contraindications Of MIS

- Presence of IDRFs (e.g., vessel encasement, intraspinal extension).
- Large tumor size with poor visualization.
- Inexperienced surgical team or inadequate pediatric setup.

IX. Recent Advances And Future Directions

- Integration of image-guided surgery, fluorescence navigation, and AI-assisted planning.
- Ongoing trials evaluating long-term oncological equivalence.
- Robotic MIS in pediatric oncology surgery being explored for precision.

X. Conclusion

Minimally invasive approaches in the surgical management of localized neuroblastoma are safe, feasible, and oncologically sound when performed by experienced pediatric surgeons. Proper case selection, avoidance of IDRFs, and interdisciplinary collaboration are key determinants of success.

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