Bangladesh Journal of Advanced Clinical Research
https://bjacr.org/index.php/bjacr
pISSN: 3105-7322 | eISSN: 3105-7314
Vol. 2, No. 2, 2024

Editorial

OPEN ACCESS

Check for updates

Advances in Pediatric Surgery: Minimally Invasive Approaches and Long-Term Outcomes

Mushtaque Ahmed[1]*

1 Department of Pediatric Surgery Rajshahi Medical College, Rajshahi, Bangladesh

Received: August 05, 2024 | **Accepted:** November 17, 2024 | **Published:** December 31, 2024

ABSTRACT

Minimally invasive surgery (MIS) has become central to pediatric surgical practice over the last three decades. Laparoscopy, thoracoscopy, and robotic assistance are increasingly standard in procedures once confined to open approaches. Evidence consistently shows MIS reduces postoperative pain, hospital stay, and wound complications, while offering superior cosmetic outcomes. More importantly, growing data confirm that long-term functional outcomes are comparable or superior to open surgery, including musculoskeletal development, fertility, and quality of life. Neonatal adaptations, the integration of Enhanced Recovery After Surgery (ERAS) protocols, and robotic platforms have expanded the scope of MIS. However, concerns persist around costs, training, and equitable access across health systems. This editorial argues that pediatric MIS must be judged not only by perioperative recovery but also by durable outcomes into adolescence and adulthood. With robust outcome reporting, structured training, and selective technology use, MIS can deliver on its promise of long-term benefit for children worldwide.

Keywords: Pediatric Surgery, Minimally Invasive Surgery, Long-Term Outcomes, Robotics, Enhanced Recovery After Surgery.

How to cite this article:
Ahmed M. Advances in Pediatric Surgery: Minimally Invasive Approaches and Long-Term Outcomes. Bangladesh J. Adv. Clin. Res. 2024;2(2): 1-4.

INTRODUCTION

Pediatric surgery has evolved dramatically since the late 20th century. The introduction of laparoscopy and thoracoscopy transformed operations that were once highly invasive into procedures requiring only a few small incisions. In adults, MIS rapidly became the gold standard for many operations, but in children, adoption was slower because of smaller anatomy, specialized equipment needs, and safety concerns. Nevertheless, the last 30 years have seen a steady shift toward MIS in both emergency and elective pediatric procedures.[1] The advantages of MIS—reduced postoperative pain, fewer wound infections, quicker mobilization, shorter hospital stays and improved cosmetic outcomes—are well documented.[2, 3] However, the debate in pediatrics is more nuanced. Because children are still developing, the long-term outcomes of surgical interventions matter as much, if not more, than early recovery. A repair performed in infancy must not only heal but also allow normal growth, organ function, and quality of life for decades to come. Thus, this editorial examines advances in pediatric MIS with a focus on both perioperative recovery and long-term outcomes, highlighting areas of consensus, persistent gaps, and future directions.

Minimally Invasive Appendectomy

Appendectomy remains one of the most common pediatric surgeries. Laparoscopic appendectomy (LA) has become the standard for uncomplicated appendicitis, offering faster recovery, shorter hospitalization, and lower wound infection rates compared to open appendectomy.[4] In complicated appendicitis, however, LA was initially controversial due to concerns over intra-abdominal abscess formation. Meta-analyses now show that LA is safe, with reduced wound infections and similar or lower abscess rates when performed by experienced teams.[5, 6] Beyond early recovery, LA may reduce

*Corresponding Authors:
Professor Dr. Mushtaque Ahmed

Doi: https://doi.org/10.70945/bjacr.v02i02.12

adhesion formation, which is an important long-term consideration in children who have decades of life ahead. Adhesive bowel obstruction is a known complication after open surgery, though pediatric data remain limited. Existing evidence suggests laparoscopy does not increase long-term adhesive complications and may in fact lower the risk.[7] From the perspective of families, cosmesis and quicker return to school are highly valued. Importantly, these advantages are not offset by higher long-term complications, confirming LA as the preferred standard for most children.[6]

Thoracoscopic Repairs (EA/TEF)

Esophageal atresia (EA) with or without tracheoesophageal fistula (TEF) is a congenital anomaly traditionally repaired via thoracotomy. While effective, thoracotomy carries risks of scoliosis, rib fusion, and long-term musculoskeletal deformities. Thoracoscopic repair was introduced to mitigate these sequelae but initially raised concerns about anastomotic leaks, strictures, and recurrent fistulas. Recent studies show that thoracoscopic EA/TEF repair achieves outcomes equivalent to open repair regarding leaks and strictures, with the added benefit of preserving chest wall growth.[8,9] Long-term follow-up into school age reveals similar rates of dysphagia and reflux, suggesting that outcomes depend more on the underlying anomaly and anastomotic tension than the surgical approach.[9] Importantly, thoracoscopy spares children the long-term morbidity of thoracotomy, making it an increasingly accepted option in specialized centers.

Neonatal Minimally Invasive Surgery

Neonates present unique challenges for MIS due to their small size and limited physiologic reserves. Insufflation of carbon dioxide can affect ventilation and circulation, raising safety concerns. Large multicenter database studies, however, demonstrate that MIS in neonates, when performed in experienced centers, has morbidity rates comparable to open surgery.[10] An analysis of over 3,000 neonatal cases from the ACS NSQIP-Peds database found no significant difference in mortality or 30-day morbidity between MIS and open approaches, suggesting that patient selection and institutional expertise, rather than the surgical approach itself, determine outcomes. Thus, MIS in neonates is feasible and safe, though careful case selection and monitoring are critical.

Enhanced Recovery After Surgery (ERAS) in Pediatrics

Enhanced Recovery After Surgery (ERAS) protocols, widely adopted in adult surgery, have gained traction in pediatrics in recent years. ERAS principles—minimizing fasting, multimodal analgesia, early feeding, and mobilization—align naturally with the goals of MIS.[11] Randomized trials in pediatric colostomy closure show that ERAS reduces length of stay and time to return of bowel function without increasing complications.[12] When combined with MIS, ERAS amplifies the benefits of minimally invasive techniques, ensuring that shorter operative trauma is matched with optimized perioperative care. This integration is particularly important in pediatrics, where early feeding and reduced opioid use support neurodevelopmental outcomes and family bonding. Innovations such as smaller robotic platforms and improved haptic feedback may broaden applications in the future. However, equitable access is a pressing concern, as many centers worldwide cannot afford robotic systems. Selective adoption, focused on procedures where robotics clearly improves outcomes, is essential to prevent unnecessary cost escalation.[13]

Function, structure, quality of life, fertility

In pediatric surgery, "long-term" must be defined in decades, not years. Outcomes of interest include normal diet, continence, unobstructed drainage, chest wall growth, spinal alignment, fertility, and quality of life. For example, thoracoscopic repair avoids rib-spreading and subsequent musculoskeletal deformities. In MIRPE, pain control and return to sports are as important as cosmetic correction. Reconstructive urologic procedures require follow-up into adolescence to ensure preserved renal function.[14] Despite the growing MIS literature, outcome reporting remains heterogeneous. Core outcome sets, including patient-reported quality-of-life measures, are urgently needed to compare techniques across centers (18). Adhesion-related fertility risks remain particularly underexplored, underscoring the need for registries linking pediatric and adult outcomes.

Equity, Training, and Global Adoption

MIS, particularly in neonates and robotics, has steep learning curves. Structured mentorship, simulation-based training, and multi-center collaborations are essential to accelerate skill

acquisition and ensure safety. Equitable access to MIS is uneven worldwide. While tertiary centers in high-income countries increasingly adopt robotics, many children in low- and middle-income regions still lack access to basic laparoscopic care. Global surgical partnerships, investment in affordable technology, and training programs are needed to close this gap.[15] Evidence suggests that outcomes in complex pediatric MIS improve with institutional volume. Regionalization of high-complexity cases and systematic mentoring can ensure that children receive safe and effective care regardless of geography.

CONCLUSION

Minimally invasive surgery in pediatrics is no longer defined by incision size but by long-term value for children. In appendectomy, thoracoscopic EA/TEF repair, and reconstructive urology, MIS provides equal or superior functional outcomes compared to open approaches, with the added benefits of reduced pain, quicker recovery, and improved cosmesis. Neonatal MIS, once controversial, is now validated as safe in experienced centers. Robotics expands possibilities but must be applied selectively to balance cost and benefit. Crucially, pediatric MIS must be judged by outcomes measured in decades: growth, fertility, function, and quality of life. The future depends on transparent outcome reporting, integration of ERAS, structured training, and equitable global access. If these principles guide adoption, minimally invasive techniques will not only shorten hospital stays but also improve the lifelong health trajectories of children who undergo surgery.

REFERENCES

1. Galazka P, Czyzewski K, Marjanska A, Daniluk-Matras I, Styczynski J. Minimally Invasive Surgery in Pediatric Oncology: Proposal of Guidelines. Anticancer Res. 2019 Nov;39(11):5853-5859. doi: 10.21873/anticanres.13789. PMID: 31704809.
2. Neogi S, Banerjee A, Panda SS, Ratan SK, Narang R. Laparoscopic versus open appendicectomy for complicated appendicitis in children: A systematic review and meta-analysis. J Pediatr Surg. 2022 Mar;57(3):394-405. doi: 10.1016/j.jpedsurg.2021.07.005. PMID: 34332757.
3. Jianyong Z, Yanruo H. Response to: Laparoscopic versus open appendicectomy for complicated appendicitis in children: A systematic review and meta-analysis. J Pediatr Surg. 2022 Sep;57(9):248. doi: 10.1016/j.jpedsurg.2022.04.016. PMID: 35599047.
4. Low ZX, Bonney GK, So JBY, Loh DL, Ng JJ. Laparoscopic versus open appendectomy in pediatric patients with complicated appendicitis: a meta-analysis. Surg Endosc. 2019 Dec;33(12):4066-4077. doi: 10.1007/s00464-019-06709-x. PMID: 30805783.
5. Rozeik AE, Elbarbary MM, Saleh AM, Khodary AR, Al-Ekrashy MA. Thoracoscopic versus conventional open repair of tracheoesophageal fistula in neonates: A short-term comparative study. J Pediatr Surg. 2020 Sep;55(9):1854-1859. doi: 10.1016/j.jpedsurg.2019.09.040. PMID: 31785836.
6. Okuyama H, Saka R, Takama Y, Nomura M, Ueno T, Tazuke Y. Thoracoscopic repair of esophageal atresia. Surg Today. 2020 Sep;50(9):966-973. doi: 10.1007/s00595-019-01884-9. PMID: 31612332.
7. Weller JH, Engwall-Gill AJ, Westermann CR, Patel PP, Kunisaki SM, Rhee DS. Laparoscopic Versus Open Surgical Repair of Duodenal Atresia: A NSQIP-Pediatric Analysis. J Surg Res. 2022 Nov;279:803-808. doi: 10.1016/j.jss.2022.04.028. PMID: 35487775.
8. Reppucci ML, Wehrli LA, Schletker J, Nolan MM, Rieck J, Fares S, Ketzer J, Rove K, Pena A, de la Torre L, Bischoff A. The effect of an enhanced recovery protocol in pediatric patients who undergo colostomy closure and Malone procedures. Pediatr Surg Int. 2022 Dec;38(12):1701-1707. doi: 10.1007/s00383-022-05213-z. PMID: 36098796.
9. Dagorno C, Montalva L, Ali L, Brustia R, Paye-Jaquen A, Pio L, Bonnard A. Enhancing recovery after minimally invasive surgery in children: A systematic review of the literature and meta-analysis. J Pediatr Surg. 2021 Dec;56(12):2157-2164. doi: 10.1016/j.jpedsurg.2021.04.004. PMID: 34030881.
10. Charras A, Smith E, Hedrich CM. Systemic Lupus Erythematosus in Children and Young People.

Curr Rheumatol Rep. 2021 Feb 10;23(3):20. doi: 10.1007/s11926-021-00985-0. PMID: 33569643; PMCID: PMC7875946.

11. Fuchs ME, DaJusta DG. Robotics in Pediatric Urology. Int Braz J Urol. 2020 May-Jun;46(3):322-327. doi: 10.1590/S1677-5538.IBJU.2020.99.03. PMID: 31961623; PMCID: PMC7088494.
12. Witjes JA, Bruins HM, Cathomas R, Compérat EM, Cowan NC, Gakis G, Hernández V, Linares Espinós E, Lorch A, Neuzillet Y, Rouanne M, Thalmann GN, Veskimäe E, Ribal MJ, van der Heijden AG. European Association of Urology Guidelines on Muscle-invasive and Metastatic Bladder Cancer: Summary of the 2020 Guidelines. Eur Urol. 2021 Jan;79(1):82-104. doi: 10.1016/j.eururo.2020.03.055. PMID: 32360052.
13. Kumar S, Bhirud DP, Mittal A, Navriya SC, Ranjan SK, Mammen KJ. Robot-assisted laparoscopic pyeloplasty: A retrospective case series review. J Minim Access Surg. 2021 Apr-Jun;17(2):202-207. doi: 10.4103/jmas.JMAS_10_20. PMID: 32964889; PMCID: PMC8083735.
14. Parrado RH, Thornburg D, Kang P, McMahon LE. Elastomeric Pain Pumps as an Adjunct for Postoperative Pain Control After Minimally Invasive Repair of Pectus Excavatum. J Laparoendosc Adv Surg Tech A. 2021 Mar;31(3):331-335. doi: 10.1089/lap.2020.0441. PMID: 33259752.
15. Uecker M, Kuebler JF, Ure BM, Schukfeh N. Minimally Invasive Pediatric Surgery: The Learning Curve. Eur J Pediatr Surg. 2020 Apr;30(2):172-180. doi: 10.1055/s-0040-1703011. PMID: 32146718.