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Lessons learned from a retrospective analysis of intestinal atresia management: implications for future practice

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ABSTRACT

Aims: Pediatric intestinal atresia poses a significant challenge for pediatric surgeons, especially in our area, where it is often treated as an emergency. Numerous factors affect patient outcomes, making it essential to identify potential management pitfalls. This study seeks to assess the management and outcomes of neonatal intestinal atresia in our institution, pinpointing challenges, pitfalls, and areas for enhancement to improve patient care and outcomes.

Methods: This is a retrospective observational study conducted at a tertiary care pediatric surgical center in Eastern India. The study spans five years, from January 2020 to June 2025, and includes all neonates and children who underwent surgery for intestinal atresia during this time.

Results: A total of 31 patients with intestinal atresia were included in this retrospective study conducted over five years. Most patients (87%) were in the neonatal age group, with only 13% presenting in the post-neonatal period. There was a male predominance, with 24 males (77.4%) and 7 females (22.6%). Two primary anatomical categories were identified: Jejunoileal atresia (JIA) was the predominant condition, observed in 24 patients (77.4%). Duodenal web or duodenal atresia was present in 7 patients (22.6%). Among the JIA cases, type 3a was the most prevalent, accounting for 22.6%. The average duration to start enteral feeding was 16 days. The mean total duration until discharge was 21.7 days. The overall mortality rate was 38.7%, with 12 out of 31 patients succumbing.

Conclusion: Children with gastrointestinal atresia often present late in their illness, experiencing significant morbidity and mortality due to factors such as poor economic conditions, inadequate nutrition, surgical challenges, and potentially related anomalies, rather than solely surgical morbidity. The high mortality rate observed in our study indicates a need to enhance our management protocols, which may be linked to delayed presentation, insufficient preoperative care, or postoperative complications. Further research is necessary to pinpoint specific areas for improvement and optimise patient outcomes.

Keywords: Infants, newborn, intestinal atresias, duodenal atresia, morbidity

INTRODUCTION

Intestinal atresias are prevalent causes of neonatal bowel obstruction. The incidence is approximately 1 in 6000, aligning with intestinal atresias' range of 1 in 5000 to 10.000 live births, typically manifesting in early life.[1] This condition stems from intrauterine vascular insults causing ischemic necrosis, resorption, and bowel segment discontinuity. Anatomically, atresias range from simple mucosal webs (type I) to complex conditions like apple-peel atresia (type IIIb) and multiple atresias (type IV).[2] Newborns typically present with bilious vomiting, abdominal distention, and failure to pass meconium. Management requires prompt surgical intervention, usually involving resection of the atretic segment with end-to-end anastomosis. In some cases, stoma formation, feeding jejunostomy (FJ), or tapering enteroplasty may be needed, based on intraoperative findings and the child's condition. Intestinal atresia challenges pediatric surgeons, particularly in our region, where it requires emergency treatment. Multiple factors influence outcomes, and identifying management pitfalls is crucial. In this retrospective study, we describe our experience with neonatal intestinal atresia, emphasizing challenges and outcomes at our institution. In our setting—a tertiary care referral hospital in Eastern India—most patients are referred after delayed presentation. Many arrive in poor condition, facing preoperative challenges like dehydration, electrolyte imbalance, sepsis, low birth weight, and poor

nutrition. Associated comorbidities such as prematurity, cardiac anomalies, or abdominal wall defects complicate management. These factors affect surgical approaches, increase complications, prolong time to full enteral feeds, extend hospital stays, and sometimes lead to poor outcomes. We compare our results with international data to identify improvements and optimize care. While literature indicates good overall survival, our outcomes are poorer compared to Western literature, prompting investigation of possible causes.

Objectives

The objectives of this retrospective study are as follows: 1. To describe the demographic and clinical characteristics of neonates with intestinal atresia. 2. To identify potential management pitfalls and their impact on outcomes. 3. To compare our outcomes with international data to inform best practices. By analyzing our experience and comparing it with global standards, we aim to enhance the care and outcomes of neonates with intestinal atresia in our region.

METHODS

The study was conducted with the permission of the All India Institute of Medical Sciences Ethics Committee (Date: 13.05.2025, Decision No: AIIMS/Pat/2025/IEC/1440). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

This retrospective observational study was conducted at a tertiary care pediatric surgical centre in Eastern India over five years (January 2020 to January 2025), encompassing all neonates and children undergoing surgery for intestinal atresia. Data were retrieved from electronic medical records and operative registries, encompassing all surgically treated cases within the timeframe. The study aimed to evaluate age at presentation, associated comorbidities, postoperative hospital stay, time to achieve full enteral feeds, whether a stoma was created, and whether a FJ or feeding gastrostomy (FG) was performed, in addition to identifying the type of atresia.

Variables collected included patient age at admission, sex, anatomical diagnosis, type of atresia, associated comorbidities (e.g., malrotation, gastroschisis, cardiac anomalies), intraoperative findings (including bowel discrepancy), and the type of surgical procedure (e.g., resection with anastomosis, stoma formation, FJ/FG placement). Postoperative complications, time to achieve full enteral feeds, duration of postoperative stay, and final outcome (discharged or expired) were recorded. Readmission and postoperative morbidity were also documented when available.

All intestinal atresias were classified based on intraoperative findings. Jejunoileal atresia (JIA) followed the Grosfeld classification: Type I (mucosal web or membrane with intact muscular and serosal wall), type II (blind-ending bowel segments connected by a fibrous cord with intact mesentery), type IIIa (complete separation of bowel ends with a V-shaped mesenteric defect), type IIIb or apple-peel atresia (proximal jejunal atresia with a large mesenteric defect and coiled distal small bowel), and type IV (multiple atresias with a "string-of-sausages" appearance.[2] Duodenal atresia was classified using the Gray and Skandalakis system: Type I (mucosal web with intact muscular wall), type II (atresia with a short fibrous cord and intact mesentery), and type III (complete separation of atretic ends, often with a mesenteric defect.[3] This classification supported prognostic assessment and surgical planning.

Descriptive statistics were used to summarize clinical and operative information. Continuous variables were reported as medians and interquartile ranges (IQR), while categorical variables were presented as absolute numbers and percentages. Comparative analyses were conducted to explore associations between atresia types, comorbidities, and clinical outcomes.

RESULTS

Patient Demographics

This retrospective study, spanning five years, included a total of 31 patients diagnosed with intestinal atresia. Most of these patients (n=27; 87%) were within the neonatal age group, while only 13% (n=4) presented during the post-neonatal period. The median age at presentation for neonates was 6 days, with an interquartile range (IQR) of 4-12 days. There was a notable male predominance, with 24 males (77.4%) and 7 females (22.6%). In the group of newborn cases, 13 cases had a birth weight under 2500 grams. Among these, five were born prematurely (before 37 weeks of gestation), and seven were found to have pneumonia along with sepsis. **Table 1** shows characteristics of patients with atresia. All patients underwent a standard antenatal ultrasound scan, yet prenatal diagnosis was confirmed in just four instances of duodenal atresia. Two primary anatomical categories were identified: JIA, which was the most common, occurring in 24 patients (77.4%), and duodenal web or duodenal atresia, found in 7 patients (22.6%). **Figure 1** illustrates the anatomical distribution of atresia, while **Figure 2** presents intraoperative images of various JIA cases.

Surgical Management

Most patients underwent resection with an end-to-oblique single-layer anastomosis. Stoma formation was performed in only one patient ((3.2%), with Meconium pseudocyst. In 6 patients (19.4%), either a FJ or FG was utilised. Feeding access was more frequently applied in cases of jejunal atresia (4 out of 24 patients) compared to those with duodenal atresia (2 out of 7 patients), indicating the common requirement for staged recovery or postponed oral intake in jejunal conditions. For FJ, a trans-anastomotic 5 French infant feeding tube was used in cases of very proximal jejunal atresia, where the blind pouch was less than 15 centimetres from the duodeno-jejunal junction and the bowel size discrepancy was 5:1 or greater. However, all patients with FJ in JIA developed a bile leak from the FJ site one week after the procedure. Essentially, the FJ site functioned as a controlled fistula (a modification in Santulli enterostomy) that provided low pressure at the anastomosis, promoting healing. Once patients began to tolerate oral feeding, the FJ was clamped, and the infants were discharged with the FJ in situ. The FJ feeding tube was removed at the first follow-up, which occurred two weeks post-discharge.

Table 1. Details of all patients with intestinal atresia

Parameter	Category	Counts	Percentages
Age subclass (n=31)	Neonatal	27	87%
	Post neonatal	4	12.9%
	Median	6	IQR 4-12.0
	IQR	5.5-11	
Sex (n=31)	Male	24	77.4%
	Female	7	22.5%
Weight (kg)	Median	1.8	IQR 1.4-3.0
Comorbidities (n=14, 45.16%)	Malrotation	4	12.90%
	CHD	4	12.90%
	RDS	1	3.22%
	Internal herniation+ CHD	2	6.45%
	Right inguinal hernia	1	3.22%
	Anorectal malformation	2	6.45%
Time to discharge (n=21)	11–20 days	8	50%
	1–10 days	7	16.6%
	21–30 days	4	8.3%
	>30 days	2	25%
	Median	18.5	IQR-9-27.5

IQR: Interquartile range, CHD: Congenital heart disease (ventricular septal defect), RDS: Respiratory distress syndrome

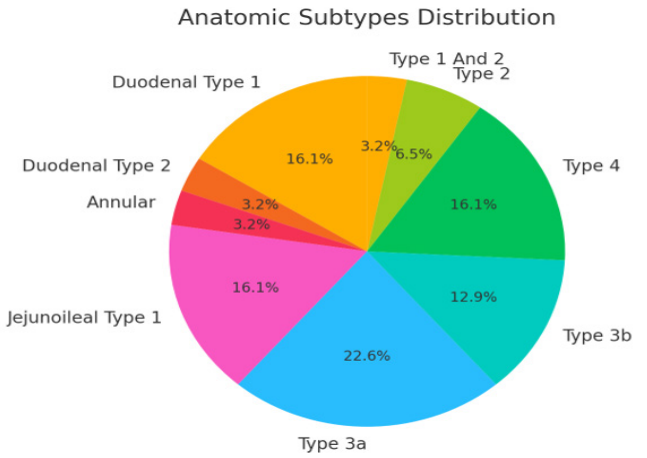

Figure 1. Anatomical distribution of atresia

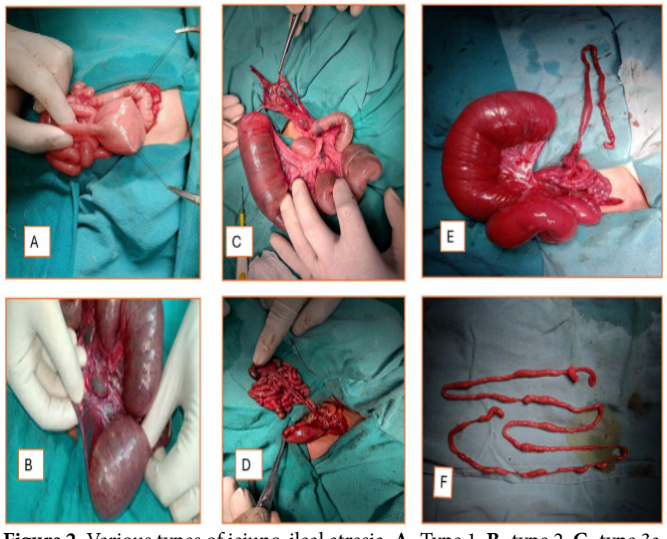

Figure 2. Various types of jejuno-ileal atresia. **A**- Type 1, **B**- type 2, **C**- type 3a, **D**- type 3b (apple peel or Christmas tree, **E**- type 4, **F**- excised large segment of small bowel in type 4 (multiple atresia)

Both the patients and their attendants were comfortable with this fistula, and the attendants were instructed on fistula care. This fistula was managed conservatively and typically healed on its own once distal bowel peristalsis was established, which could take up to 3-4 months post-surgery. All these patients achieved 100% survival.

Intraoperative Findings

- Bowel discrepancy-the most frequent ratio was ≥5:1 (n=23; 74.2%), followed by ≤5:1 (n=8; 25.80%)
- Meconium pseudocyst and dense adhesion were seen in 6.45% (n=2)
- Devitalized bowel due to volvulus of a segment of bowel was also seen in 6.45% (n=2).

Postoperative Outcomes

The mortality rate was 38.7%, with 12 out of 31 patients passing away, while 19 patients, accounting for 61.3%, were discharged. **Table 2** provides details of all the patients who expired.

Table 2. Details of expired patients

No of expired patients (n=12)	Details of patients
4	Preoperative sepsis
2	Devitalised bowel (1), type 4 atresia (1)
2	Delayed presentation (≥10 days of life)+anastomotic leak
2	Premature with low birth weight (<1500grams)+CHD
2	Post discharge*

*Both patients were confirmed to have expired after discharge through telephonic communication. These individuals exhibited prolonged ileus and failure to thrive. All these cases weighed less than 2500 grams with lumen disparity ≥5:1. CHD: Congenital heart disease

The median time to full enteral feeds was 16 (IQR- 8.5-22.0) days. Total parenteral nutrition (TPN) was not available for any patient. Postoperative feeding was done by partial parenteral nutrition using dextrose in Ringer's lactate, parenteral amino acids, and multivitamins. The typical duration of a hospital stay after surgery was 21.7 days on average, with a median of 18.5 days, indicating that some patients experienced extended recovery periods as inpatients (**Table 1**).

Postoperative Complications

- Postoperative complications occurred in 20 patients (64.51%).
- Adynamic ileus was the most commonly seen in 12 patients (60%) all in JIA patients with lumen disparity ≥5:1.
  - » Pneumonia (mostly due to aspiration and prolonged immobility) was seen in 7 patients (35% of complications)
  - » Reoperation was done in 5 (3 anastomotic leaks+2 adhesive obstructions) patients (16.12% of complications)
  - » Anastomotic leak was seen in 3 patients (15% of complications).
  - » Neonatal jaundice: 5 patients (25% of complications)

» Surgical wound infection occurred in 1 patient (05%) (**Table 3, 4**).

Table 3. Postoperative complications

Serial No.	Postoperative complications
1.	Adynamic ileus (n=12)
2.	Pneumonia (n=7)
3.	Neonatal sepsis and jaundice (n=5)
4.	Reoperation (n=5)
5.	Anastomotic leak (n=3)
6.	Surgical wound infection (n=1)

Table 4. Summary of results

Parameter	Summary
Age subclass	Median age 6 days (IQR 4–12)
Sex	Male predominance (M: F≈3:1)
Weight	Majority low birth weight (IQR 1.4-2)
Anatomic classification	Majority had jejunoileal atresia
Outcome	Mortality rate: 38.7%
Discrepancy category	Most had lumen discrepancy ≥5:1
Complications	Adynamic ileus and pneumonia most common
Stoma	Rare (only 1 case)
Feeding jejunostomy/gastrostomy	Used in 19.4% of cases
Length of hospital stay	Median time to discharge: 18.5 days

DISCUSSION

Intestinal atresia is a birth defect where a section of the intestine fails to develop completely, leading to significant bowel obstruction in infants. The survival rates and long-term prognosis are heavily influenced by the type and location of the atresia, as well as any related abnormalities. Although improvements in neonatal care have enhanced survival rates over the past few decades, there are still notable disparities, especially in developing nations.

Our research underscores the difficulties encountered in treating intestinal atresia in environments with limited resources. The patient demographics reveal a predominance of males (77.4%) and a majority of neonates (87%). Intestinal atresias frequently lead to bowel obstruction in newborns, and in our study, the majority of patients were diagnosed during the neonatal period.

The gender distribution in our study contrasts with international findings. While many studies indicate a nearly equal occurrence between genders, our research identified a male predominance.[1,4,5] This variation might be due to factors such as population-specific characteristics, genetic influences, or differences in study methodologies.

In our area, it is quite common for surgical neonates to experience delayed presentation and high mortality rates. This study found that the median age of neonates was 6 days, with an interquartile range of 4 to 12 days. A similar study from India and Pakistan indicated that approximately 78% of neonates with intestinal atresias presented after 48 hours.[1,6] Researchers in Nigeria and Ethiopia have reported similar findings, with 63.2% and 72% of cases, respectively, exhibiting delayed presentation.[7,8]

In our context, several factors contribute to the delay in referring patients from peripheral centers. These include inadequate neonatal care, which leads to delayed diagnosis, and some families' reluctance to disclose the disease to others. A significant observation in our group was the notable percentage (13%) of post-neonatal cases and the considerable number of patients arriving with inadequate nutritional reserves and related comorbidities. Additionally, the absence of prenatal detection has further contributed to delayed presentation. This delay increases the risk of complications, including sepsis and respiratory compromise. This is in contrast to centers with early antenatal diagnosis and referral pathways where timely surgical correction leads to improved outcomes.[9,10]

In our study, JIA emerged as the most prevalent condition, accounting for 77.4% of cases, with type 3a and type 4 being the most frequently observed subtypes. This aligns with international findings where type 3a is commonly seen.[11-13] The anatomical classification followed Grosfeld's modification for JIA and Gray & Skandalakis' for duodenal atresia, allowing standardization of operative planning.

In our study, a significant bowel lumen discrepancy (greater than 5:1) was observed in the majority (74.2%) of cases, likely due to delayed presentation. This delay leads to prolonged stagnation of bowel contents, followed by intense peristaltic activity, ultimately resulting in the affected segment becoming more dilated, hypertrophic, and lacking peristalsis.

In our review of the literature, we did not identify any classification system that specifically addresses the difference between the proximal and distal bowel segments in cases of intestinal atresia. While some studies referred to a "gross discrepancy," they did not specify dimensional criteria. Interestingly, in many instances where there was a significant difference in bowel diameter, other researchers chose to create a stoma.[12,14] However, in our series, we avoided forming a stoma even when the bowel diameter discrepancy was greater than 5:1, as this could result in high stoma output and malabsorption, which we are not well-prepared to handle due to the limited availability of TPN. Instead, we performed oblique anastomosis in all such cases and, in some situations, inserted a trans-anastomotic FJ, which might be a novel technique. The site of the FJ developed into a controlled fistula, which not only decompressed the dilated bowel but also reduced pressure at the anastomotic site, thereby aiding in healing.

In our study, 45.16% of intestinal atresia cases were found to have associated anomalies. This aligns with other research, which indicates that such anomalies occur in 30-75% of cases, with duodenal atresias more frequently exhibiting these associated anomalies.[1,6,15]

In the majority of cases, primary anastomosis was carried out. Stomas were avoided except in one patient who had a meconium pseudocyst and dense adhesions, due to the

risk of complications like fluid and electrolyte imbalance, stoma prolapse, and delays in restoring bowel continuity. Techniques such as tapering enteroplasty and managing luminal discrepancies were used selectively. Our findings indicate varying discrepancy ratios, with most exceeding a 5:1 ratio, which allowed for safe anastomosis without significant complications. Importantly, six patients needed FJ or gastrostomy because of severe proximal dilation or related motility problems, aligning with literature that supports feeding access in complex situations.[16-18]

The high complication rate of 64.5% observed in our study can be attributed to delayed presentation, suboptimal neonatal intensive care, and limited resources. Patients presenting with additional anomalies and low birth weight, who require further treatment, are more susceptible to complications. This situation results in unacceptably high morbidity, extended hospital stays, and increased medical costs. A similar study reported a lower complication rate among their patients.[7,19,20]

Our research determined that the median duration to achieve full enteral nutrition was 16 days. In instances of JIA, this duration was significantly extended compared to duodenal atresia, with median durations of 19 and 8 days, respectively. Several established factors can affect the time required to attain full enteral intake and, consequently, the length of hospital stay. These factors include sepsis, significant luminal discrepancy, prolonged adynamic ileus, and the necessity for additional surgical interventions. These findings are consistent with those reported in other studies. Previous research has suggested that the time to full enteral feeding is also influenced by the type of JIA (jejunal or ileal), the remaining bowel length, the presence of short bowel syndrome, and other concurrent congenital anomalies.[20,22]

Our overall mortality was 38.7%, which is significantly higher than reported in developed healthcare systems. The causes of mortality were multifactorial, including sepsis, respiratory distress, and severe comorbidities such as congenital heart disease. Despite these challenges, 19 patients (61.3%) were successfully discharged.

Mortality rates for JIA are significantly lower in high-income countries, with survival rates approaching over 90%, compared to low- and middle-income countries, where survival rates remain considerably lower, ranging from 58% to 71.5%.[4,23,24]

The advancements in managing atresia, such as the adoption of laparoscopy, bowel lengthening methods (serial transverse enteroplasty (STEP), Bianchi procedure (longitudinal intestinal lengthening and tailoring-LILT), and spiral intestinal lengthening and tailoring (SILT)), and innovative anastomotic techniques, underscore the improvements in surgical treatment. Nonetheless, in resource-limited environments like ours, the focus should remain on early detection, prompt referral, and precise intraoperative procedures.[25,26]

Limitations

Our study, being retrospective, is subject to certain limitations, including the presence of missing data for deceased patients and the absence of long-term follow-up. Nevertheless, it represents one of the most extensive recent series from Eastern India, highlighting the urgent need for enhancing perinatal detection and neonatal care pathways.

Upon analysing the results, we identify several factors contributing to the elevated mortality rates.

- Insufficient prenatal screening for congenital anomalies results in delays in diagnosis and referral, causing most patients to arrive at the emergency department already suffering from sepsis and pneumonia.
- The lack of pediatric surgical care facilities in remote areas led to delayed treatment and adverse outcomes.
- The absence of TPN in our institution restricted our capacity to deliver optimal postoperative care, thereby contributing to poor outcomes.
- Patients exhibited a negative nitrogen balance due to delayed diagnosis and treatment, adversely affecting postoperative outcomes.
- In instances of significantly dilated and hypertrophic pouches, resection was unfeasible due to the risk of short bowel syndrome, resulting in complications and mortality.
- Cases involving type 4 atresia necessitating resection of extensive bowel segments experienced high mortality rates due to short bowel syndrome and the inability to provide adequate nutrition.

CONCLUSION

To sum up, our research emphasises the difficulties and intricacies involved in treating intestinal atresia in environments with limited resources. Despite these obstacles, we have gained important insights that can lead to improved care and outcomes for these at-risk patients. Our results highlight the necessity for better perinatal detection, timely referrals, and accurate surgical procedures to boost the survival rates and quality of life for newborns with intestinal atresia. We aspire that our experiences will aid in the ongoing initiatives to enhance pediatric surgical care in our area and beyond, ultimately offering hope and healing to the families and children impacted by this condition.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of the All India Institute of Medical Sciences Ethics Committee (Date: 13.05.2025, Decision No: AIIMS/Pat/2025/IEC/1440).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Brace yourself: a critical look at YouTube videos on pectus carinatum-is YouTube trustworthy for health info?

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ABSTRACT

Aims: YouTube is a widely accessed platform for health-related information, but the reliability and quality of its content remain questionable. This study aimed to evaluate the informational and overall quality of YouTube videos related to pectus carinatum using standardized scoring systems.

Methods: A systematic search was conducted in March 2025 using the keywords "pectus carinatum" and "pectus carinatum children". Videos were filtered based on relevance, language (English), and content inclusion criteria. A total of 34 videos were analyzed. Two pediatric surgery specialists independently assessed the videos using the DISCERN and Global Quality Scale (GQS). Statistical analyses were performed to explore correlations between video characteristics and quality scores, as well as differences based on the source of upload.

Results: The mean DISCERN and GQS scores were 53.7±16.46 and 3.47±0.94, respectively. Approximately 41% of videos were classified as high quality based on DISCERN, while 47% were considered high quality based on GQS. Videos uploaded by professional organizations had significantly higher scores than those by individual users ($p<0.05$). There was no strong correlation between view counts or likes and the quality scores. Upload time was not significantly associated with video quality.

Conclusion: The quality and informational value of YouTube videos related to pectus carinatum vary significantly, with content from professional sources generally offering higher reliability. This underscores the importance of healthcare professionals and academic institutions taking an active role in producing scientifically accurate, unbiased, and up-to-date content on digital platforms.

Keywords: Pectus carinatum, YouTube, misinformation

INTRODUCTION

YouTube is one of the most widely used social media platforms globally. It is considered the second most popular search engine after Google and hosts millions of daily users.[1] Its accessibility and extensive reach have significantly contributed to its role in disseminating health-related information.[2] YouTube is known to be utilized in health research and by patients attempting self-diagnosis.[3] The quality and reliability of health content on YouTube vary significantly across topics, raising concerns about its efficacy as an information source for patients.[4]

Pectus carinatum is the second most common chest wall deformity, characterized by the protrusion of the sternum and adjacent cartilage. This deformity is usually mild during childhood but becomes more pronounced during adolescence. Conservative treatment with compression bracing can largely correct this condition.[5]

Patients with pectus carinatum may experience issues such as low self-esteem and social withdrawal.[6] As the diagnosis relies entirely on clinical examination,[7] the quality of YouTube content is important in helping patients evaluate themselves, access timely treatment and continue daily social activities through effective management. Thus, this study aimed to evaluate the quality of YouTube content on pectus carinatum as a health information resource using internationally recognized rating scales. To our knowledge, this is the first study to systematically evaluate the reliability and quality of

YouTube videos related to pectus carinatum, highlighting the need for evidence-based content and the crucial role of healthcare professionals in digital health communication.

METHODS

As this study analyzed publicly available YouTube videos, it did not involve human or animal experiments; hence, ethical approval was not required. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In March 2025, searches were performed on YouTube (www.youtube.com) using the keywords "pectus carinatum" and "pectus carinatum children". To minimize the influence of YouTube's recommendation algorithm and ensure objective results, both viewing and search histories were cleared and paused prior to data collection. All searches were conducted in a new browser session with cleared cookies and cache. Additionally, videos were listed without applying any personalized ranking criteria or filters and only the default search results were analyzed.

Videos containing any relevant information on pectus carinatum were included in the analysis. Their universal applicability. Videos unrelated to pectus carinatum, repetitive content, or videos lacking any written or verbal information were excluded. Due to limited available content, videos of 29 seconds or longer were included in the analysis. Considering most users stop browsing after a certain page, videos beyond the 5th search results page were not analyzed.[8] A total of 34 videos met the inclusion criteria.

Video details, including links, upload dates, duration, view count, like count, and uploader identity (individual or organization), were recorded. Two pediatric surgeons (>7 years of clinical experience) independently rated the videos using two scoring systems. Preliminary scoring on 10 videos revealed an intra-class correlation coefficient (ICC) of 0.92. Final scores represented the average ratings, and discrepancies exceeding 5 points did not occur, eliminating the need for a third evaluator. Videos were categorized based on uploader type: institutional, physician, and patient-generated. The DISCERN (standardized tool used to assess the reliability and quality of health information;16 items, scores ranging from 15-80) scale, used for assessing written health information quality,[9] and the Global Quality Scale (GQS, 5-point scale that evaluates the overall quality, flow, and usefulness of video content) for subjective video quality evaluation[10] were utilized. DISCERN scores ≥60 indicated high quality, scores between 40-59 moderate, and scores <40 low quality. GQS scores ≥4 indicated high quality, scores between 2.5-3.5 moderate, and scores ≤2 low quality.

Statistical Analysis

Data were analyzed using SPSS 28.0 (IBM Inc., Armonk, NY, USA). Descriptive statistics were calculated for all variables initially. The Shapiro-Wilk test assessed data normality, and non-parametric methods were chosen for non-normally distributed data. Comparisons of DISCERN and GQS scores based on source type used the t-test for normally distributed data and Mann-Whitney U test for non-normally distributed data. Relationships between video duration, views, likes, and DISCERN and GQS scores were analyzed using Spearman correlation. The same method assessed the relationship between video upload time (days) and scores. Multiple linear regression models, using log-transformed views and likes as independent variables and DISCERN and GQS scores as dependent variables, assessed the explanatory power of views and likes. A two-sided p-value <0.05 was considered statistically significant for all tests, and tables were generated.

RESULTS

A total of 34 YouTube videos related to pectus carinatum were analyzed. The mean duration of videos was 196.5±123.5 seconds, with a median duration of 196 seconds. The average view count was 27.719±69.678, ranging from 14 to 384.847 views. The median number of likes was 54.5, with an average of 231.4±576.6 likes (**Table 1**). These findings indicate varying popularity among videos.

Table 1. Descriptive statistical characteristics of the analyzed YouTube videos

	Time (sec)	View count	Number of likes	DISCERN[1]	GQS[2]
Mean	196.52	27719.08	231.35	53.7	3.47
Std	123.49	69677.96	576.6	16.46	0.94
Min	29	14	0	20	1.5
Max	612	384847	3200	76	5
Median	196	5157	54.5	54.5	3.5

1. A standardized tool used to assess the reliability and quality of health information. 2. A 5-point scale that evaluates the overall quality, flow, and usefulness of video content. GQS: Global Quality Scale, Min: Minimum: Max: Maximum

DISCERN scores ranged from 20 to 76, with an average score of 53.7±16.46. The average GQS score was 3.47±0.94 (**Table 1**). This variability highlights significant quality differences between the videos.

Approximately 41% of videos were rated as high quality according to DISCERN scores, 35% as moderate, and 24% as low quality. According to GQS scores, about half (47%) of the videos were high quality, 38% moderate, and 15% low quality (**Table 2**). This distribution suggests varying quality levels, with overall moderate-to-high quality content and some low-quality videos.

Table 2. Distribution of video quality according to DISCERN and GQS scores

	DISCERN[1]		GQS[2]	
Quality	**Number of videos**	**%**	**Number of videos**	**%**
High	14	41.17	16	47.05
Medium	12	35.29	13	38.23
Low	8	23.52	5	14.7

1. ≥60 indicated high quality, between 40-59 moderate and <40 low quality. 2. ≥4 indicated high quality, between 2.5-3.5 moderate and ≤2 low quality. GQS: Global Quality Scale

Analysis revealed a very strong positive correlation between views and likes (r=0.98), indicating popular videos also received more likes. Moderate positive correlations were found between video duration and DISCERN (r=0.35) and GQS scores (r=0.33), suggesting longer videos might not

always be more informative. Conversely, weak correlations were observed between views, likes, and DISCERN and GQS scores (r≈0.09-0.18), indicating popularity does not directly correlate with content quality (**Table 3**).

Table 3. Correlations between video characteristics and DISCERN and GQS scores

	Time (sec)	View count	Number of likes	DISCERN	GQS
Time(sec)	1	0.03	0.056	0.35	0.33
View count	0.03	1	0.97	0.17	0.14
Number of likes	0.05	0.97	1	0.13	0.08
DISCERN	0.35	0.17	0.13	1	0.97
GQS	0.33	0.14	0.08	0.97	1

GQS: Global Quality Scale

Significant differences in DISCERN and GQS scores based on uploader type were observed ($p<0.05$). Institutionally uploaded videos demonstrated higher quality compared to those uploaded by individuals. Weak negative correlations were noted between upload date and DISCERN ($r=-0.23$; $p=0.196$) and GQS scores ($r=-0.21$; $p=0.237$), suggesting upload timing had minimal impact on content quality scores (**Table 4**).

Table 4. Comparison of DISCERN and GQS scores based on video source and upload time

Comparison	Statistical test	Test statistic	p-value
Institutional vs. individual–DISCERN score	Mann–Whitney U test	231.5	0.00
Institutional vs. individual–GQS score	Mann–Whitney U test	221	0.00
Upload date vs. DISCERN score	Spearman rank correlation	-0.22	0.19
Upload date vs. GQS score	Spearman rank correlation	-0.20	0.23

GQS: Global Quality Scale

DISCUSSION

In this study, YouTube videos related to pectus carinatum were evaluated using DISCERN and GQS. Our findings highlight substantial variability in content quality among the videos, reflecting inconsistency in the reliability of online health information. YouTube videos potentially influence patients' decision-making processes, yet the marked variability in content quality remains a critical concern.[11]

The finding that only 41% of videos were classified as "high-quality" by DISCERN scoring indicates that patients should exercise caution when accessing health information online. Similarly, GQS scores revealed approximately 47% of videos to be high quality, whereas a significant portion remained moderate or low in quality. These findings, in line with previous studies conducted on various medical topics, indicate that the overall quality and reliability of YouTube videos remain suboptimal in certain areas of health-related content.[4,12]

Another significant result from our study is the absence of meaningful relationships between views/likes and DISCERN/GQS quality scores. Correlation analyses demonstrated very weak relationships (r≈0.09–0.18), underscoring that a video's popularity on YouTube does not directly equate to its informational or educational quality. Although it is often assumed that users evaluate content primarily based on superficial factors such as entertainment value, visual appeal or popularity metrics, the findings of that study suggest otherwise. The results indicated that users do not generally consider view or like counts as indicators of quality. Instead, they tend to trust professional sources and frequently compare information across multiple videos in order to assess objectivity and reliability.[13] One previous study noted that although view counts do not reliably reflect content quality, like and interaction ratios might partially indicate relevance.[14] Likewise, a systematic review reported that there was no meaningful correlation between the number of views or likes and the quality of health-related videos.[15] Therefore, relying solely on the metrics of views or likes as markers of content reliability or educational value can be misleading.

Moderate positive correlations were observed between video length and both DISCERN and GQS scores ($r=0.35$ and $r=0.33$, respectively), suggesting that longer videos generally offer more comprehensive and informative content. Findings from other studies also support the notion that increasing video duration can enhance overall quality scores.[12,14] Nevertheless, the moderate strength of this correlation in our study suggests that increased length alone does not guarantee superior quality. Clearly structured, evidence-based, and unbiased presentation of information is equally as critical as video duration.

Analyses based on upload sources revealed significant differences in DISCERN and GQS scores ($p<0.05$). Videos uploaded by institutional sources displayed notably higher quality compared to individual user-generated content. This finding indicates higher reliability and credibility associated with professional healthcare institutions, hospitals, and academic bodies. Consistent with our results, prior research assessing videos on celiac disease similarly reported higher quality from professional and institutional sources.[16] Another study focusing on pediatric surgery identified potential misinformation risks in individual user-generated videos.[17] Individual-uploaded content often exhibited poorer quality, potentially attributed to a lack of academic scrutiny, consequently increasing misinformation risk.[18] Therefore, professionally sourced videos from credible organizations contribute positively to patient education and informed decision-making in healthcare settings.

Conversely, no significant relationship was detected between video upload date (days since upload) and content quality scores. Neither DISCERN nor GQS scores showed meaningful change or improvement over time, suggesting content recency alone is not a sufficient indicator of quality. This finding implies that users' preference for recently uploaded content may not necessarily lead them to accurate or reliable health information. Jana et al.[19] demonstrated that even recently published videos addressing public health concerns such as

monkeypox infection predominantly featured low-quality and misleading content. Similarly, Mohamed and Shoufan[13] argued that users often rely on inadequate criteria when favoring newer videos, disregarding critical assessments of content quality. Zhaksylyk et al.[20] emphasized that content recency alone does not assure reliability, underscoring the importance of ethically constructed and scientifically verified information.

Overall, findings from our study indicate YouTube's potential for disseminating valuable information on specific health conditions such as pectus carinatum. However, careful evaluation of content is essential. One study acknowledged YouTube's role as a complementary tool for patient education and medical students' training,[21] although another highlighted the necessity of rigorous quality control mechanisms for health-related content.[22] Furthermore, improvements in YouTube's recommendation algorithms, incorporating stricter regulatory and filtering mechanisms, are strongly recommended to ensure higher content reliability.

Limitations

The present study has some limitations. First, our analysis included only the initial set of videos identified through specific search keywords and did not account for YouTube's personalized recommendation algorithm, potentially limiting generalizability. Second, the evaluation process relied on subjective scales such as DISCERN and GQS, and despite assessments being conducted by trained evaluators, individual interpretive differences could affect the results. Lastly, limiting the analysis to English-language videos and performing assessments within a specific timeframe further constrain the applicability of our findings.

CONCLUSION

The quality and informational value of YouTube videos related to pectus carinatum vary significantly, with content produced by professional sources generally presenting higher quality. Increasing the visibility of healthcare professionals and academic institutions on digital platforms, alongside generating unbiased, scientifically grounded, and current content, would substantially enhance YouTube's potential as a public health resource. Additionally, expanding access to such content could reduce misinformation and assist patients in making informed health decisions.

To further improve the reliability of online health information, we propose the development of a "quality certification" system for health-related videos and recommend integrating peer-reviewed sources into YouTube's ranking algorithm.

Through this study, we aim to underscore the crucial role of healthcare professionals in shaping the quality of online health information. By actively producing evidence-based, trustworthy content and by embracing digital platforms as tools for public engagement, healthcare providers can play a pivotal role in counteracting misinformation and supporting informed health decisions.

ETHICAL DECLARATIONS

Ethics Committee Approval

As this study analyzed publicly available YouTube videos, it did not involve human or animal experiments; hence, ethical approval was not required.

Informed Consent

Since this study analyzed publicly available YouTube videos and did not involve human or animal experiments, informed consent was not required.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Manual detorsion allows time for orchidopexy in testicular torsion

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ABSTRACT

Aims: To investigate the efficacy of color Doppler ultrasound (CDUS)-guided manual detorsion (MD) as an immediate intervention in pediatric testicular torsion (TT) and its impact on testicular preservation, surgical timing, and postoperative outcomes.

Methods: A retrospective analysis was conducted on 43 pediatric patients who underwent surgery for TT between July 2019 and January 2025. Patients were divided into two groups based on whether MD was attempted prior to surgery (MD group, n=15) or not (non-MD group, n=28). MD success was defined by symptom resolution and confirmed reperfusion on CDUS. Data on symptom duration, time to surgery, intraoperative findings, orchiectomy rates, contralateral testicular fixation (CTF) feasibility, and postoperative complications were compared between groups.

Results: MD was successful in 14 of 15 cases (93.3%), significantly prolonging the median time to surgery (11±5.9 hours) compared to the non-MD group (2.0±1.28 hours; $p<0.001$), allowing for improved surgical conditions. Orchiectomy was avoided in all successful MD cases but required in four patients in the non-MD or failed MD group. Testicular atrophy occurred only in the non-MD group. CTF was more frequently performed in the MD group due to reduced scrotal edema. No recurrences or major complications were observed in the MD group during follow-up.

Conclusion: CDUS-guided MD is a safe and effective temporizing maneuver that facilitates testicular salvage and surgical planning in TT. However, timely orchidopexy following successful MD remains essential to prevent residual torsion or recurrence and to ensure optimal outcomes.

Keywords: Testicular torsion, manual detorsion, orchidopexy, reperfusion

INTRODUCTION

Testicular torsion (TT) is a clinical emergency in which the testicular cord and vessels twist around themselves, disrupting the blood supply to the testicle and, if left untreated, resulting in testicular loss. The time to salvage the testis after TT is very short. Research shows that ischemic changes can start within 4 to 6 hours, making prompt intervention crucial. If detorsion does not happen within 24 hours, about 80% of patients may face orchiectomy due to necrosis.[1,2] Urgent scrotal exploration and detorsion are recommended as the standard surgical method for testicular salvage.

In TT, where hours or even minutes are crucial for saving the testicle, the time to surgery may be prolonged due to preoperative preparation and hospital resources.[3] Manual detorsion (MD) is the correction of torsion by an external maneuver in the opposite direction of torsion. Nash first described TT in 1891 as a case report in which surgery was performed, followed by the same author in 1893, who described a complete regression of complaints and findings with external MDs without surgery.[4] The testicles are usually torsioned from lateral to medial. In detorsion, a maneuver like opening a book from medial to lateral is recommended.[2] However, if this maneuver is unsuccessful, it has been reported to be successful with the maneuver performed in the opposite direction.[5] After detorsion, the pain is relieved, and the testicle descends into the scrotum.[6,7] MD can be performed during physical examination or immediately with a Color Doppler Ultrasound (CDUS) guide. Success is proven when blood flow is seen again on CDUS at this time.[8]

It is essential to perform the procedure with CDUS to diagnose torsion and control blood flow after MD. In the diagnosis of TT, CDUS is the gold standard diagnosis with

100% sensitivity, 97.9% specificity, and 98.1% diagnostic accuracy.[9] CDUS can detect even the direction and number of cord twists,[8] which is essential information when performing MD under CDUS guidance. After MD, a normal CDUS should document a complete detorsion of the spermatic cord and testicular blood flow in the affected testicle.[8,10]

In our study, we aimed to present the results of our patients to whom we applied MD before surgery for TT.

METHODS

The study was conducted with the permission of the Scientific Researches Ethics Committee of Bursa City Hospital (Date: 16.04.2025, Decision No: 2025-8/2). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The records of patients who underwent surgery with the diagnosis of TT between July 2019 and January 2025 were retrospectively reviewed. Perinatal torsion cases were excluded from the study. The patients' age, symptom duration, MD intervention, surgical waiting time, surgical findings, surgical method applied, and early and late postoperative complications were analyzed. MD success was confirmed by the sudden decrease in symptoms and reperfusion monitoring on CDUS. Patients who did not undergo MD (non-MD group) and those who underwent MD (MD group) were compared in terms of duration of symptoms, time to surgery, orchiectomy, and atrophy.

MD method: The examining physician is on the patient's right side, holding the testicular elements proximal to the inguinal canal with one hand in a slightly palpable position along the canal. In contrast, the other hand rotates the affected testicle from medial to lateral as if opening a book. The number of rotations continues until the testicle descends into the scrotum, and the pain suddenly subsides. The procedure is performed with CDUS, and the return of blood flow confirms the success of the procedure.

Statistical Analysis

All data analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Not normally distributed data were presented as median (minimum-maximum). Categorical variables were expressed as numbers and percentages (%). Comparisons between two independent groups were made using the Mann-Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. $p<0.05$ was considered statistically significant.

RESULTS

During the study period, 43 patients with a mean age of 13.39±2.68 (5-17) were treated with the diagnosis of TT. Twenty-five (58%) patients had the left testicle affected, and 18 (42%) had the right testicle affected.

Fifteen (35%) patients with confirmed TT diagnosis in the MD group, and 28 (65%) patients in the non-MD group. The demographic and timing comparison of the groups is presented in **Table 1**. The median symptom duration of patients presenting to the emergency department due to TT was 7.00 (range: 1-84) hours, and there was a significant difference between the two groups ($p<0.001$). In the MD group, except for one patient, symptom duration was shorter than 24 hours in 14 patients. MD was attempted in 15 patients and was successful in 14 (93.3%) patients. The patient with an unsuccessful MD had a symptom duration of 48 hours. The median time between presentation to the emergency room and surgery was significant difference between the two groups ($p<.001$). The median degree of torsion in the non-MD group was 720 (360-1080) degrees. There was no torsion in 13 of 14 patients who underwent successful MD, and one patient had testicular circulation but 180 degrees of residual torsion. There was a minimal color change in the detorsion testicles that underwent successful MD. In one patient who underwent an unsuccessful MD, it was observed that there were 1080 degrees of torsion, and the testicle was necrotic.

During surgery, contralateral testis fixation (CTF) was performed in all patients in the group with successful MDs. CTF was not performed in 5 patients (4 patients in the non-MD group and one patient with unsuccessful MD) due to severe scrotal edema. One (20%) of the five patients presented with contralateral TT 3 weeks later and had orchidopexy following successful MD. Elective orchidopexy was performed on one patient one month later. The follow-up of the remaining three patients continues without CTF at the family's request.

MD and non-MD group results are presented in **Table 2**. A total of 4 patients underwent orchidectomy. No orchidectomy

Table 2. Clinical outcomes in MD and non-MD groups

Outcome	MD group (n=15)	Non-MD group (n=28)
Successful MD	14 (93.3%)	–
Orchiectomy	0	4
Atrophy during follow-up	0	5
Postoperative complications	0	4 (3 wound leakage, 1 dehiscence)
CTF performed	14	23

MD: Manual detorsion, CTF: Contralateral testicular fixation

Table 1. Demographic and clinical characteristics of patients with testicular torsion

Characteristics	Total (n=43)	MD group (n=15)	Non-MD group (n=28)	p-value
Age, years, mean (min–max)	13.39 (5–17)	12.66 (5–17)	13.78 (5–17)	0.21
Pain duration, hours, median (min–max)	7.00 (1–84)	2.00 (1–48)	24.00 (2–84)	<0.001
Time from diagnosis to surgery, hours, median (min–max)	4.00 (0.5–20)	11.00 (1.00–20)	2.00 (0.5–5)	<0.001

Data are presented as mean (min–max) or median (min–max). p: p-value. *p<0.05 indicates statistical significance. MD: Manual detorsion, Min: Minimum, Max: Maximum

was performed in patients with successful MDs. In the early postoperative period, three patients in the non-MD group experienced incision leakage, and one patient had an incision opening. There were no early postoperative complications in the MD group.

The average follow-up period of our patients is 67 (4-64) months. During the follow-up period, atrophy developed in 5 patients who were in the non-MD group. No atrophy was observed in patients who were successful in the MD group. Since the group that underwent MD and was successful included patients who came within the first 24 hours, no atrophy was observed in the group that did not undergo MD under the same conditions when patients with a symptom duration of less than 24 hours were evaluated.

DISCUSSION

TT is an emergency surgical condition that develops when the testis, vascular and cord structures twist around themselves and rapidly progress to ischemic necrosis. Time is critical in saving the testicle.[11,12] Therefore, the duration of diagnosis and intervention from the onset of symptoms is decisive for testicular survival.

The degree of torsion and the length of ischemic time are the main determinants of testicular damage.[10,13] In our study, the median value of the symptom duration at the time of presentation to the emergency department was 7 (range: 1–84) hours. The decision to perform MD was made according to the severity of scrotal edema and hyperemia, the duration of symptoms, and the preference of the surgeon performing the intervention. A total of 15 patients underwent MD, 14 of which were successful. The symptom duration in the only unsuccessful case was over 24 hours. Dias Filho et al.[14] applied MD only to patients with symptoms for less than 24 hours.Vasconcelos-Castro et al.[10] argued that MD can be applied to all patients regardless of the duration of symptoms and that there should be no contraindication to trying MD. In our study, MD was not applied to patients who had pain complaints for more than 24 hours due to the edematous appearance of the scrotum, and it was not successful in one patient. Our clinical opinion on this issue is that MD should not be applied if clinical findings such as scrotal edema and redness are severe, as well as the duration of pain. In our patients who applied in less than 24 hours and did not receive an MD, the preference of the surgeon who applied the first treatment differed. As a result of all these, the patients in the MD group had shorter symptom duration than the group in the non-MD.

Since Nash defined MD in 1893, articles have been published on the benefits of MD.[3,6,10,14] CDUS is essential both in the diagnosis of TT and in proving the effectiveness of MD.[9,10] Today, even the direction of torsion and the number of torsions can be seen with CDUS.[8] This increases the safety of CDUS-guided MD applications.[15] In all of our patients, TT was diagnosed with CDUS by emergency medicine specialists or radiologists, and simultaneous control CDUS was performed on patients who underwent MD. MD was applied to 15 patients, and in 14 (93.3%), a sudden improvement in pain and blood flow was restored in the testicle. One patient had no improvement in clinical and CDUS findings and was taken to emergency exploration. Patients who underwent successful MDs were not discharged immediately; they were hospitalized and taken to surgery in more stable conditions.

Patients in the non-MD group are taken to surgery as soon as possible after diagnosis. The median time from presentation to surgery in the MD group was 11±5.91(1.00-20) hours, and the median time from surgery in the non-MD group was 2.00±1.28 (0.5-5) hours. The two groups had a significant difference (p<.001). The application of MD allowed for a more comfortable surgery by making the patient's preoperative preparation easier and reducing edema and symptoms. We generally do not recommend discharge to our patients. A normal CDUS after MD cannot be used as the sole factor to evaluate MD as successful because standard CDUS cases have been reported in TT.[16] In one of our patients, 180-degree torsion was observed during surgery despite some improvement in testicular blood flow. Vasconcelos-Castro[10] argued that this residual TT would be diagnosed more clearly with RDUS and complete resolution of pain and that proof of MD success with RDUS alone would not be sufficient. Session et al.[2] reported that 18 patients (32%) had an average of 360 degrees of residual torsion at surgery, and despite symptomatic improvement, some patients still had significant spermatic cord rotation at surgery. Other studies have also published these findings.[14,17] In patients whom we consider to have successful MD, orchidopexy should be planned as soon as possible due to the possibility of residual torsion. We recommend semi-urgent orchidopexy before discharge in all patients.

It has been reported that 80% of patients with ischemic scrotum require orchiectomy after 24 hours due to necrosis.[1,2,12] The degree of torsion and the length of ischemic time are the main determinants of testicular damage.[10,13] In our study, the median degree of torsion in the non-MD group was 720 (360-1080) degrees. There was no torsion in 13 of 14 patients who had successful MD, and one patient had 180 degrees of residual torsion, although there was testicular circulation. Orchiopexy was performed in all patients who had successful MDs. Orchiectomy was performed in 4 patients, 3 of whom were non-MD and one of whom was unsuccessful MD due to testicular necrosis. All patients who underwent orchiectomy had symptoms longer than 24 hours and torsion degrees of 720 and 1080 degrees. Orchiectomy was not performed in any patient with a successful MD. Although MD is considered advantageous in terms of orchiectomy, we cannot make a standard comparison regarding orchiectomy because patients with symptom duration longer than 24 hours and severe clinical findings were not in the successful MD group. In addition, our study demonstrated a high success rate of MD (93.3%). This may reflect the relatively short symptom duration and selected cases in our cohort. However, Sessions et al.[2] reported residual torsion at surgery in a notable proportion of cases despite clinical improvement, highlighting that symptomatic relief and Doppler reperfusion may not guarantee complete detorsion. Similarly, Vasconcelos-Castro et al.[10] reported variable outcomes of MD, with lower success rates and emphasized that a normal

CDUS alone may not reliably exclude incomplete detorsion; therefore, orchidopexy should not be delayed even when apparent improvement is observed.

It is known that complete recovery in clinical and radiological findings with MD is insufficient for treatment. Information on recurrence should be provided in patients who do not undergo orchidopexy. We received information that one of our patients who applied to us with TT and to whom we applied MD successfully had applied for MD at another center with a diagnosis of TT 15 days before his application. We hospitalized the patient after a successful MD and performed testicular fixation under semi-emergency conditions. Successful MD saves us significant time from diagnosis to surgery. This situation becomes even more critical, especially during referrals from a center where there is no surgical facility at the center where the patient was first diagnosed. Discharge to home and elective surgery recommendations may also be appropriate after a successful MD. However, due to the uncertainty of residual TT and recurrence, referral to a center that will perform surgery as soon as possible would be appropriate.

CTF is generally recommended in TT, except in neonatal torsions. Bell clapper anomaly is associated with an increased risk of intravaginal TT. Contralateral bell clapper anomaly is common in older boys with acute TT, supporting its standard application in this clinical setting.[18-21] CTF is performed because of the risk of contralateral TT.[22] However, some authors argue that the risk of contralateral TT is low and that CTF should not be performed to avoid surgical trauma to the testis during fixation. Some experimental data indicate the potential adverse fertility effects of transparenchymal fixation sutures, depending on how CTF is performed.[23] Our clinical approach is to add CTF at the same session in TT, except in neonatal TT, which is generally accepted.

CTF was applied to all patients in the MD successful group, while it was not applied to 5 patients in the non-MD group because the scrotum was very edematous. CTF was easily applied in our patients since we operated on the group in which MD was applied in semi-emergency conditions with the regression of findings such as edema and redness. However, in the non-MD group, CTF was not applied during this period when inflammation was intense in cases where the scrotum was very edematous and hyperemic. MD facilitated the decision and application of CTF. MD provided the opportunity for the safe application of CTF. Contralateral TT occurred in one of the five patients (20%) who did not receive CTF after 3 weeks, and the family applied one hour after the pain because they were conscious. MD was applied to the patient successfully, and emergency testicular fixation was applied. Although it is not significant for a small number of patients, the rate of contralateral TT in our series is high. Therefore, applying CTF in the same session may be important. Elective CTF was applied to one patient one month later in a different session. The families of the remaining three patients to whom CTF was not applied were informed about contralateral TT. They were taken under clinical follow-up with the family decision, recommending an urgent application in case of a complaint related to the testicle. It is essential to provide this information to the patient's families and obtain their consent to be informed about this.

Possible complications after orchidopexy include recurrent ipsilateral or contralateral torsion, testicular ischemia and atrophy, and adverse effects on fertilization.[24,25] In our study, ipsilateral TT did not occur in either group. Contralateral torsion occurred in one patient. We discussed this issue in the CTF paragraph. Atrophy was not seen in any patient in the MD group but in 5 patients in the non-MD group. Atrophy was seen in patients who presented more than 24 hours later in the non-MD group. However, no significant difference was seen between the two groups regarding atrophy in patients with symptom duration less than 24 hours. The mean follow-up period of our patients was 67 (4-64) months.

Limitations

This study has several limitations. First, it is retrospective in nature and conducted at a single center, which may limit the generalizability of the findings. Second, the sample size is relatively small, and the number of events such as orchiectomy and contralateral torsion is limited. Third, the follow-up period was relatively short and variable across patients, which restricts the ability to evaluate long-term outcomes such as fertility and recurrent torsion. These factors should be considered when interpreting our results.

CONCLUSION

As a result, performing an MD before surgery in TT is vital for testicular reperfusion, for which hours are essential. MD does not eliminate the need for surgery but can provide more controlled surgical planning. It saves time for patient referrals from centers that do not have surgical treatment options. Considering the risk of residual torsion and recurrence after MD, patients should undergo orchidopexy as soon as possible after a successful MD.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of the Scientific Researches Ethics Committee of Bursa City Hospital (Date: 16.04.2025, Decision No: 2025-8/2).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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MHA MEDIHEALTH ACADEMY

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Original Article

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Microsurgical varicocelectomy in pediatric and adolescent patients with varicocele: a single-center experience

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ABSTRACT

Aims: Varicoceles, which can occur in children, are known to cause future male infertility, testicular pain, and testicular atrophy. Their treatment is primarily surgical—in adults, microsurgery is the standard treatment; however, in children, laparoscopic surgery is widely performed. This study aimed to evaluate the efficacy of microsurgery in patients with varicoceles aged ≤18 years.

Methods: The retrospective study was conducted from December 2016 to April 2025 and included male patients aged ≤18 years who underwent microsurgical varicocelectomy at Yokohama City University Medical Center. The summary statistics were calculated.

Results: The median age of this study's 36 participants was 15 years, and the most common symptoms were testicular pain (25 cases) and scrotal swelling (11 cases). The mean right and left testicular volumes were 15.3 ml and 14.2 ml, respectively, with no significant difference between them (p=0.09). There were 12 cases with a difference in testicular volume of ≥2 ml or ≥20% between the affected and unaffected sides. The median number of veins ligated was 11. Two arteries and the three lymphatic vessels as the median were preserved, respectively. The chief complaint—testicular pain or swelling—was resolved in all cases.

Conclusion: Varicoceles can develop in childhood and may cause scrotal pain, testicular atrophy, and male infertility. Microsurgical varicocelectomy may be a safe and effective treatment option for children with varicocele.

Keywords: Varicocele, pediatrics, adolescent, varicocelectomy

INTRODUCTION

Varicoceles are commonly encountered in adult males. The prevalence rate is reported to be 0.79% in aged 2-6 years, 0.96% at 7-10 years, 7.8% at 11-14 years and 14.1% at 15-19 years.[1] A varicocele is defined as the enlargement of the spermatic cord's pampiniform venous plexus. While some questions remain unanswered, a previous study has suggested three etiologies of varicoceles.[2] First, the left spermatic vein flows into the left renal vein at a right angle, predisposing it to increased pressure. Second, the left spermatic vein has a long path before it flows into the inferior vena cava, predisposing it to increased pressure during blood return. Third, the left spermatic vein may lack venous valves, predisposing it to reflux-induced pressure increments.

Varicoceles are known to cause male infertility, testicular pain, and testicular atrophy.[3] They can lead to seminal oxidative stress, which increases the likelihood of sperm functional and morphological abnormalities and apoptosis.[4] Furthermore, they cause increments in testicular temperature due to blood stasis in the venous plexus, leading to spermatogenic dysfunction.[5] Consequently, semen parameters are impaired, leading to male infertility. Although the mechanism underlying testicular pain is unclear, it has been reported to occur when dilated veins compress the surrounding nerve fibers.[3] As a person's fertility status cannot be evaluated before puberty, varicoceles are sometimes detected due to testicular pain in boys.[3] Varicoceles are graded in accordance with worldwide guidelines, which classify them into three grades.[3] Grade 3 can be diagnosed by visual examination. Grade 2 can be diagnosed by palpation in the standing position. Grade 1 can be diagnosed by palpation under the Valsalva maneuver in the standing position. Treatment is primarily surgical, with microsurgical varicocelectomy becoming the standard approach. According to the European Association of Urology guidelines, in children with varicoceles, a testis is considered to be hypotrophic if the volume discrepancy

between it and the contralateral testis exceeds 2 ml or 20%, and varicocelectomy is strongly recommended in such circumstances.[6]

There have been few reports on microsurgery in pediatric and adolescent patients. However, microsurgical varicocelectomy has been increasingly made available for children as medical technology is advancing and more sophisticated medical equipment is becoming more available. In this study, we retrospectively reviewed cases at our hospital to confirm the efficacy and safety of microsurgical varicocelectomy in patients aged ≤18 years.

METHODS

Ethics

The protocol for this research was approved by the Ethics Committee of Yokohama City University Medical Center (Date: 26.05.2021, Decision No: B210300044). The study was conducted following the provisions stipulated in the Declaration of Helsinki. Consent was obtained via the opt-out method; hence, patient consent was assumed.

Study Design

The study included male patients aged ≤18 years who underwent microsurgical varicocelectomy at the Department of Urology, Center for Reproductive Medicine, Yokohama City University between December 2016 and April 2025. Varicocele was diagnosed by physical examination with Doppler ultrasonography according to Dubin and Amela grading system.[7] In principle, varicocelectomy was indicated when the patient had clinical varicocele, and the testicular volume discrepancy between the affected testis and the contralateral testis exceeded 2 ml or 20%, or the patients had refractory scrotal pain.

The breakdown of indication for surgery, the patient's age, height, weight, testicular volume, laterality, grade of varicocele, and the number of vessels ligated or preserved during surgery were confirmed. After surgery, complications, recurrence, and symptom disappearance were evaluated.

Surgical Procedures: Microsurgical Subinguinal Varicocelectomy

All patients underwent surgery under general anesthesia. A 2–3-cm incision was made directly above the external inguinal ring, and the spermatic cord was identified and secured. Under a microscope, the external and internal spermatic veins were all ligated and resected while the artery and lymphatic vessels were preserved (**Figure**). All vessels were counted regardless of their thickness. A Doppler flowmeter was used in cases in which it was difficult to identify the arteries or distinguish them from veins.

Statistical Analysis

Continuous variables are presented as mean values with standard deviations when normally distributed or median values with interquartile ranges when skewedly distributed. Categorical variables are presented as frequencies with percentages. Comparisons between continuous variables were performed using Student's t-test or the Mann–Whitney U test for normally and skewedly distributed data, respectively. Categorical variables were compared using the Chi-square test or Fisher's exact test as appropriate. The threshold for statistical significance was set at $p<0.05$.

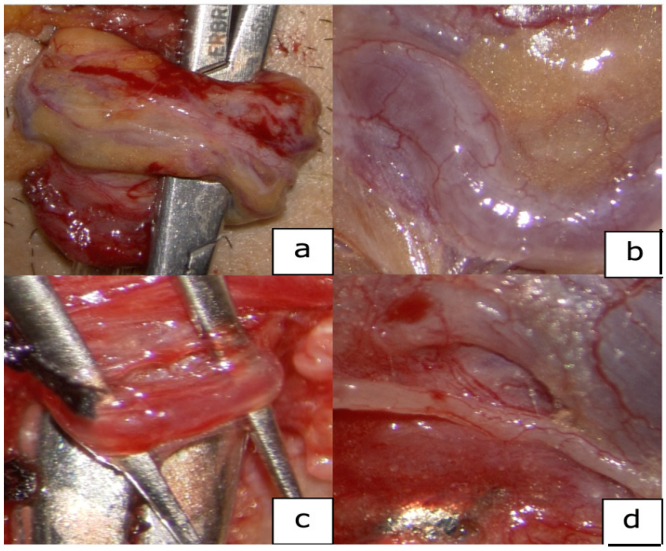

Figure. Vascular structures observed during microsurgical subinguinal varicocelectomy **a.** Spermatic cord contents after dissection of the external and internal spermatic fascia. **b.** Isolated spermatic vein. **c.** Isolated spermatic artery. **d.** Isolated lymphatic vessel

RESULTS

Among the 36 participants, the main complaint was testicular pain in 25 cases and scrotal swelling in 11 cases. Patient characteristics are shown in **Table 1**. The median age, height, and weight were 15 years, 169 cm, and 55 kg, respectively. The mean right and left testicular volumes were 15 ml and 14 ml, respectively. There was one case of bilateral varicocele, 34 cases of grade 3 varicocele, and two cases of grade 2 varicocele. The mean right and left testicular volumes were 15.3 ml and 14.2 ml, respectively, with no significant difference between them (p=0.09). There were 12 cases with a difference in testicular volume of ≥2 ml or ≥20% between the affected and unaffected sides. The median number of veins ligated was 11. Two arteries and the three lymphatic vessels as median were preserved, respectively (**Table 2**). Complications of surgery occurred in two cases—one case of hematoma and one case of recurrence. The chief complaint—testicular pain or swelling—was completely resolved in all cases postoperatively.

Table 1. Patient`s background

Variables	Median (mean±SD), number (%)
Age (years old)	15 (15.2±2.5)
Height (cm)	169 (167.1±9.3)
Weight (kg)	55 (55.1±11.4)
Right testicular volume (ml)	15 (15.3±3.3)
Left testicular volume (ml)	14 (14.2±3.3)
Bilateral	1 (2.8%)
Grade 3 varicocele	34 (94%)

SD: Standart deviation

Table 2. Operation findings

Variables	Median (mean±SD)
Resected vein	11 (12.7±4.4)
Preserved artery	2 (2.3±1.4)
Preserved lymphatic vessel	3 (4.1±2.3)

SD: Standard deviation

DISCUSSION

Varicoceles are known to cause male infertility and testicular pain in adults. In children, delayed development of the unaffected testis has been reported to occur due to the presence of varicoceles.[8] Therefore, the presenting complaints of children often differ from those of adults, with testicular pain, scrotal swelling, and scrotal asymmetry being common reasons for seeking medical care. In this study, testicular pain was reported in 69% of cases and scrotal swelling in 31%, suggesting that testicular pain is the more common presenting complaint in children with varicoceles.

In recent years, male infertility has become a major medical issue, and awareness of varicoceles in adults has increased dramatically as a result. The treatment of varicocele-induced testicular pain includes analgesics and surgery. The severity of varicocele-induced testicular pain varies widely, ranging from sudden and severe pain to mild discomfort. There was also significant individual variation in the duration and frequency of this pain. In some cases, the condition is self-limiting; for example, in approximately 15% of cases, there is spontaneous resolution of pain.[9] If sufficient improvement is not achieved with conservative treatment, surgery should be considered. Previous studies have reported that surgery improves testicular pain in approximately 80% of patients.[3] Cases in which pain was more likely to improve with surgery included those with low-grade varicoceles, those with chronic pain, and patients with a low body-mass index.[10-12]

In patients with varicoceles, there is a possibility of testicular atrophy on the affected side.[8] It is considered that varicoceles adjacent to the testicles create a high-temperature environment around them, leading to testicular atrophy. A previous study reported that in adolescent males, the rates of testicular volume asymmetry were 36% and 10% in patients with and without varicoceles, respectively.[8] The study followed changes in testicular volume in patients, and ultimately, 17% and 3% of patients with and without varicoceles had testicular volume asymmetry, respectively. The disappearance of the testicular volume discrepancy between the left and right sides was attributed not only to the catch-up growth of the affected testis but also to atrophy of the contralateral one.[8] On the other hand, according to some reports, the presence or absence of varicoceles in adults is not related to testicular volume discrepancies.[13] Therefore, careful judgment is required when deciding whether surgery is appropriate due to testicular atrophy. In addition, it is more important to discuss if the repair of varicocele and testicular asymmetry will result in an increase of paternity through improvement of testicular function. Cayan et al.[14] conducted long-term study including 408 adolescent patients between 12 to 19 years old with clinical varicocele and compared the effect of surgical intervention and conservative follow-up. The study showed the paternity rate was significantly higher in the microsurgical varicocele repair group than in control group (77.3% vs 48.4%, OR 3.63, p<0.005), and the time to conception was significantly shorter in the microsurgical varicocele repair group than in the control group (11.18±6.5 months vs 16.85±6.9 months, p<0.005). This study supports the benefit of varicocele repair for adolescent patients with varicocele. However, the number of studies with long-term follow-up is still few. More studies are needed to examine its efficacy for pediatric and adolescent patients in long-term benefit.

Several surgical techniques for varicocele management exist, each with its own advantages. The choice of technique depends on the location where the vein is ligated. The common method is retrograde gonadal vein ligation, which is performed via open surgery, laparoscopic surgery, or microsurgery. The open retroperitoneal approach has the advantages of fewer veins to ligate and minimal risk of arterial injury; however, it is highly invasive and associated with high complication and recurrence rates.[15] Laparoscopic high ligation is less invasive than open surgery and has fewer complications.[16-18] Microsurgery requires longer surgical procedures and skilled techniques; however, it is associated with low complication and recurrence rates.[19,20] It is often the first choice for adults and should also be considered for children. Recent meta-analyses of randomized controlled trials on varicoceles in children have shown that microsurgical varicocelectomy is highly effective but requires advanced technical skills.[21,22]

In this study, all patients presented with testicular pain or scrotal swelling as the primary complaint. Microsurgical varicocelectomy was performed under general anesthesia, and all patients reported improvement in their primary symptoms. Although objective assessment of testicular pain and scrotal swelling was difficult, based on the patient's subjective assessment, the symptoms completely resolved. When testicular volume asymmetry was defined as a volume discrepancy of ≥2 ml or ≥20% between the left and right testes, 12 cases were identified in which testicular volume asymmetry was incidentally detected. No patients underwent surgery for testicular atrophy, so catch-up growth was not followed.

While there are many studies reporting the efficacy of laparoscopic surgery for varicoceles in children,[18,23,24] studies on microsurgical varicocelectomy are scarce. Microsurgical varicocelectomy is minimally invasive and associated with low rates of complications and recurrence.[20] In previous study, it is reported that postoperative hydrocele occurred in 6.6% of cases and recurrence in 2.2% of cases following laparoscopic surgery.[25] On the other hand, although the total number of cases was small, no hydrocele occurred in this study and the recurrence rate was 2.8%. The reason for the absence of hydrocele is likely due to the lymphatic vessels being identifiable during surgery. The advantage of microsurgery is that it allows the precise identification and preservation of tissue and vessels. Our study demonstrated favorable outcomes of microsurgery in children and adolescents with varicoceles, although it entailed just short-term follow-up. Therefore, despite the requirement of advanced technical skills and learning curves, we believe that

it should be considered the first-choice surgical approach for both children and adults.

Limitations

This study has several limitations. First, testicular volume was not tracked, and catch-up growth could not be confirmed. No cases underwent surgery due to differences in testicular volume between sides; therefore, testicular volume was not tracked in this study cohort. After surgery, varicocele disappearance was confirmed, and follow-up was discontinued if no symptoms were present. Second, testicular pain was not evaluated objectively such as using pain scales. Changes in symptoms were confirmed by comparing the patient's subjective symptoms. Symptoms were compared by conducting interviews before and after surgery. Third, our hospital has a large number of microsurgical cases, allowing us to perform microsurgery on pediatric patients. However, it may not be feasible for all hospitals to consider it as the first-line procedure as microsurgery in pediatric patients is technically challenging.

CONCLUSION

Varicoceles can develop in childhood and may cause scrotal pain, testicular atrophy, and male infertility. Microsurgical varicocelectomy is safe and effective for children with varicoceles.

ETHICAL DECLARATIONS

Ethics Committee Approval

The protocol for this research was approved by the Ethics Committee of Yokohama City University Medical Center (Date: 26.05.2021, Decision No: B210300044).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Family presence in pediatric resuscitation

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ABSTRACT

Resuscitation refers to medical interventions and practices performed in emergency situations such as cardiac arrest or respiratory arrest in order to restore the individual's life findings with physiological, pharmacological and mechanical methods. Pediatric resuscitation is a process that is different from adults due to anatomical and physiological differences in pediatric patients and includes specific protocols, as well as a critical process that includes both physical and emotional dimensions for both healthcare personnel and patient relatives. The physical participation of family members or relatives in this process is a very important, multifaceted and highly controversial issue both ethically and psychologically. Patients and their relatives often expect to be actively involved in treatment and health care decisions. Similarly, even during resuscitation and critical care, patients want their relatives to be with them and family members/relatives may also want to be present. Family presence enables family members to participate in or witness the resuscitation process when the child's life is in danger. The physical presence of parents for children and relatives for adult patients in the resuscitation room, as well as their involvement in decision-making processes, are essential components of family presence. Family presence during resuscitation is a tripartite relationship that affects health professionals, family members and the care of the child. All needs must be balanced in the context of effective resuscitation in family presence, as actions involving all three groups can affect the others.

Keywords: Cardiac arrest, family presence, health professionals, pediatric resuscitation

INTRODUCTION

The issue of family presence in resuscitation is still a controversial issue today. Resuscitation refers to medical interventions and practices performed in emergency situations such as cardiac arrest or respiratory arrest in order to restore the life findings of the individual with physiological, pharmacological and mechanical methods. Pediatric resuscitation is a critical process that includes both physical and emotional dimensions for both healthcare personnel and patient relatives, as well as being a process that includes specific protocols different from adults due to the anatomical and physiological differences of pediatric patients. With the right information and support, the active involvement of families in the care of the child can facilitate the healing process for both the child and the family.[1] Many healthcare institutions offer various educational programs to ensure the active participation of family members in the treatment process of their children, especially in pediatric care. Families' presence with the child during critical processes such as emergencies and resuscitation, and being informed about the process, can lead to a less traumatic experience of resuscitation and a healthier grieving process.[2]

FAMILY PRESENCE IN RESUSCITATION

Resuscitation includes medical interventions such as basic life support and advanced life support. The physical participation of family members or patient relatives during these interventions is a very important, multifaceted and highly controversial issue, both ethically and psychologically. The concept of resuscitation in the presence of family members was first reported to have emerged in 1982 at Foote Hospital in Michigan, USA, after two incidents in which family members refused to leave the room during resuscitation of their loved one, and this led to the initiation of a program in which the issue of the presence of family members in resuscitation was discussed, allowing family members to participate in resuscitation in a planned manner.[3] In 1992, Hanson and Strawser conducted a nine-year study on family presence during resuscitation and developed procedures and policies to standardize family presence practices in resuscitation. Many organizations universally support family presence during resuscitation.[4] In 1993, the emergency nurses association (ENA) was the first organization to endorse family presence during resuscitation. At the same time, ENA has published interdisciplinary guidelines and training

manuals on the practice of family presence during invasive procedures and resuscitation. ENA's 1995 training program emphasized the importance of family members being with the patient during resuscitation.[5] In 2010, ENA made the striking statement, "Without written policies for the family, emergency department staff may be compromising practice and depriving patients/families of the emotional support they need".[6] The American heart association (AHA) advocated for family presence resuscitation in 2000. It has also published guidelines recommending that family members be allowed to be present during resuscitation attempts.[7] Both the AHA and the ENA have emphasized that current evidence supports resuscitation in the presence of the family and that this practice is beneficial.[8,9] The World Health Organization (WHO) (2003) has argued that the family should be involved in the process for approval of invasive procedures in resuscitation, and therefore cultural factors should be considered during communication with the family. Similarly, additional policies on neonatal resuscitation were developed by the WHO in 2012 and 2016, but remarkably did not recommend family presence in neonatal resuscitation.[10,11]

The European resuscitation council (ERC) guideline reported that many families desire to be with both the resuscitated relative and other family members during the resuscitation period, while the ERC supported giving relatives the option to attempt resuscitation in a manner sensitive to cultural and social differences.[12,13]

The ERC published guidelines on this issue in 2005;[14]

- Considering family presence as an option during pediatric procedures and resuscitation attempts,
- Informing the patient's relatives that the environment during resuscitation may have a negative impact on the family,
- If the family does not wish to be present during resuscitation, a written form must be completed,
- That the safety of the resuscitation team is always considered,
- Identifying procedures and reviewing hospital policies related to family witnessed resuscitation practice in hospitals,
- He recommended the organization of training programs for personnel who will perform family witnessed resuscitation.[12,15]

Family presence enables family members to participate in or witness the resuscitation process when the child's life is in danger. The physical presence of parents for children and relatives for adult patients in the resuscitation room, as well as their involvement in decision-making processes, are essential components of family presence. During pediatric resuscitation, the presence of parents in the intervention room reduces the child's level of stress and anxiety and provides families with the opportunity to learn about their child's treatment process and make decisions.[1]

The applicable aspects of family presence in pediatric resuscitation in health care settings can be presented under the following headings:

Physical participation: Presence of family members in the intervention room/resuscitation room while the child is being resuscitated

Psycho-emotional support: Family members provide moral support and emotional support to the child

Communication and information: Transparently informing family members about resuscitation room dynamics and medical interventions

Participation in decision-making processes: Families play an active role in medical decision-making for critical decisions in resuscitation, such as termination of life support.[1,2,16]

FAMILY CENTERED CARE

In the field of health, pediatric patients were isolated from their parents until the 1960s with the idea that nurses would provide better care to the sick child than their parents.[17,18] After 1961-1978, parents started to be supported in caring for their children and evidence-based studies were needed to put family-centered care into practice.[19,20] Research in the field of psychology and psychopathology by Robertson, Spitz, Bowlby, Harlow, Ainsworth emphasized the importance of the mother and parent in the care of the child, and it was determined that maternal deprivation delays recovery and affects the child's personality and mental health in later life, thus demonstrating the need for a family-centered care model.[21] Family-centered care is a health care approach that shapes the daily interaction between health policies, management of health institutions, patients, families, and members of health disciplines (doctors, nurses, paramedics, physiotherapists, dieticians, etc.).[22] It has been described as a family-centered care, i.e. a partnership approach to health decision-making.[19] The aim of family-centered care is to preserve the bonds between the child and the family, to ensure the family's participation in the care of the child, to ensure that the child feels safe in the hospital environment, and to prevent the negative effects of hospitalization on the child and the family.[23,24]

The active participation of the family in care positively affects the child's physical, psychological and emotional health, and the presence of parents increases the child's sense of security by reducing separation anxiety. In a study conducted by Byers et al.[25] on 114 preterm infants and their parents, it was found that preterm infants in the group receiving family-centered care had less crying behavior and stress levels and required less analgesics. Melnyk and Feinstein[26] found that negative behavioral changes were significantly reduced in children whose family members participated in health care.

In 2015, O'Brien et al.[27] conducted a study by providing training to the families of babies in the neonatal unit and found that there was an increase in the feeding rate and

weight gain of babies and that the anxiety levels of family members who actively participated in the care of the baby decreased. With the increasing importance of family-centered care in health care delivery, the participation of families in health care decisions has increased, and some policies and procedures supporting the absence of the family during resuscitation have started to be changed.[6,28]

THE ROLE OF FAMILY IN PEDIATRIC RESUSCITATION

Pediatric resuscitation is a critical situation that requires taking into account the emotional and psychological vulnerabilities of children. The family's presence in the pediatric resuscitation process plays an important role in meeting the emotional needs of the child. Children need to be supported psychologically as well as physically in emergency situations. Having parents by their child's side can be critical to reassure them and help them cope with stressful situations.[29]

Being with people they love and trust can reduce anxiety and increase emotional resilience. Parents are a strong source of support for their children, even if they have to deal with their own fears and anxieties during the resuscitation process. Giving parents the opportunity to connect emotionally when faced with the risk of their child's death provides a healthy start to the grieving process.[30]

The presence of this emotional bond is one of the most important factors preventing family members who witnessed the death of their child from becoming emotionally closed in the post-mortem process.[31] Family presence in pediatric resuscitation provides both the child and family members with the opportunity to support each other, reduces feelings of helplessness, fear and hopelessness, and allows parents to share their feelings with their children who are in the last moment of life. However, the involvement of families in the resuscitation process reduces the sense of isolation of adult and pediatric patients and contributes psychologically to the healing process.[2] The family's presence in this process is critical to meet the emotional needs of the child, as well as to contribute to the psychological recovery of parents and other family members. This is because resuscitation not only targets the physiological recovery of the child, but also affects the emotional and psychological state of the family, and parents can experience great psychological stress as they watch their child being treated in an emergency.[31]

Many professional organizations have identified a number of potential benefits for relatives regarding family presence in resuscitation. It can be traumatic for family members to witness the resuscitation process of a loved one. However, some research has suggested that family witnessing the resuscitation process can help families recover emotionally and reduce the likelihood of suffering from post-traumatic stress disorder (PTSD).[2-16] Family presence during resuscitation can positively affect the crisis management of family members and allow for a healthier grieving process. Therefore, proper support of family members during resuscitation is essential.

HEALTH PROFESSIONALS AND FAMILY PRESENCE

Family presence during resuscitation was first raised in the United States in the 1980s. Twibell et al. [32] emphasized that "family presence" is a right for families to see the interventions and practices performed on the patient during the resuscitation process. Family presence is an issue that needs to be taken into consideration by health professionals who have become more dominant and specialized especially in resuscitative procedures. Accordingly, family presence during resuscitation is a practice that is currently being discussed in many countries.[13] Family presence raises various ethical issues. For example, the trauma experienced by family members while watching resuscitative interventions may influence the decision-making of health professionals. However, in some cultures, the relationship between patients and their family members may influence the decision to resuscitate and lead to an ethical problem. Therefore, healthcare professionals should carefully consider how family members will be involved in the resuscitation process and, when appropriate, family members should be offered the opportunity to participate in resuscitation.[32] In 2010 the American Association of Critical Care Nurses (AACN) emphasized that "family members of patients undergoing resuscitation and invasive intervention procedures should be given the opportunity to be present in the room". Family presence during resuscitation is the most natural right for all patients. Although family presence during resuscitation is an increasingly widespread health practice, it is highly debated by health professionals in terms of its risks and benefits.[15,33,34] Health care professionals are concerned about the possibility of family members interfering with the resuscitation process in the presence of family members in resuscitation, the possibility of interruption of care and treatment, the difficulty of terminating cardiopulmonary resuscitation (CPR), etc., resulting in long and unnecessary interventions that the patient will not benefit from. The concerns and worries of health care professionals on this issue affect the advocacy of family presence in resuscitation.[5,33] In addition to these barriers, it has also been reported that the lack of ergonomically suitable areas for family positioning in emergency and intensive care units, which are the units where resuscitation procedures are most frequently performed, is an obstacle to the practice of family presence in resuscitation.[12] Despite this, it has been reported that health care professionals generally perceive family presence in resuscitation as risky for the patient and themselves, but they find family presence beneficial for the patient's relatives and the quality of resuscitation is not affected by family presence.[13] Healthcare professionals should always advocate for family presence in resuscitation, recognizing the benefits of family presence during resuscitation practice.[6] When the literature is reviewed, it is reported that practices regarding family presence in resuscitation differ from country to country. The practice of family presence resuscitation has been significantly accepted in the United States,[35] the United Kingdom,[36] Canada[37] and Australia.[38] However, in Germany,[39] Turkiye,[40] Iran,[41] Jordan,[42] Spain[43] and Singapore[44] family presence in resuscitation remains a controversial topic that

is not clinically accepted due to potential physical risks to healthcare professionals. International resuscitation councils and associations emphasize family presence in resuscitation and the need to support families in this regard.[6,33]

RESEARCH RESULTS ON FAMILY PRESENCE IN RESUSCITATION

Different opinions and results have been reported in studies on family presence in resuscitation. In a 2017 study by Alshaer et al.[45] investigating the perceptions of Saudi families regarding resuscitation in adult intensive care, it was reported that 60.9% of the individuals stated that they wanted to be present during the resuscitation of their relatives, while it was determined that they similarly wanted their relatives to be present during resuscitation if they were resuscitated themselves. In a study conducted with 15 patients and 570 relatives of patients who underwent CPR in the prehospital area, it was found that resuscitation efficiency, CPR duration, drug selection and survival rate were not affected by the presence of family in resuscitation.[46] Doyle et al.[3] reported that 72% of families preferred to be in the resuscitation room and 71% of health care professionals supported the practice of resuscitation in the presence of the family in a study in which 55 family members and 21 health care professionals participated in the emergency department of Foote Hospital in 1985. In a study conducted by Kocaaslan et al.[47] with 487 nursing students, 61.4% of the student nurses thought that the family should not be present during the procedure, 55.6% thought that the presence of the family during the procedure would cause distress, 91.4% thought that the family should not be present during the procedure due to the risk of emotional reaction, and 63.7% stated that they would want to be present if one of their family members was being resuscitated. In the same study, it was reported that only 13.3% of students approved the presence of family in pediatric resuscitation[47] and in a study conducted by Düzkaya et al.[48] in pediatric clinics, 73.8% of healthcare professionals thought that the presence of family in resuscitation would create problems and negatively affect working conditions. In another study conducted by Lederman et al.[49] similarly, it was found that the majority of healthcare workers (71.6%) thought that family presence should not be allowed in resuscitation.

In Finland, the family members of 12 patients whose relatives were hospitalized in the intensive care unit were asked for their opinions on family presence during resuscitation, and it was found that the family members of most patients stated that they wanted to be present if their patients were resuscitated.[50] Afzali et al.[51] presented some evidence that relatives who witnessed the resuscitation of their loved ones, whether successful or not, experienced less anxiety and PTSD. Meyers[52] reported that violent behaviors of family members present in the room during resuscitation may prevent the resuscitation process when they lose emotional control, and this situation may also cause health professionals to focus on family members rather than the patient. Badır and Sepit[53] found that the presence of family in resuscitation prevents the motivation of the resuscitation team and accordingly, the stress level of resuscitation team members increases and their performance decreases. In the literature review, studies conducted to determine the risks related to family presence in resuscitation were also found.[50,51] As a result of a study, five main themes were identified regarding the risks of family presence in resuscitation: increased stress and anxiety levels of health professionals, the possibility of lawsuits against health professionals by family members, the risk of family members interfering with resuscitation, traumatic experiences, and the possibility of family members distracting health personnel.[51] It has been reported that healthcare professionals, especially family members, make inappropriate comments during resuscitation, seek errors in medical diagnosis, care and treatment processes, and therefore, the possibility and risk of suing healthcare professionals is high. Another important theme is that relatives of patients may tend to show violence against healthcare professionals and may harm healthcare personnel performing resuscitation.[49,51] Some research shows that having family members, especially parents, together in the final moments of their child's life helps to make the bereavement process less traumatic. Having family members together after the death of their child helps the family to heal emotionally and supports and strengthens the emotional bond between family members. Moreover, as parents grieve the loss of their child after the death of their child, sharing the child's life and final moments together can help to come to terms with the loss.[52]

CONCLUSION

Family presence during resuscitation is a tripartite relationship that affects health professionals, family members and the care of the child. All needs must be balanced in the context of effective resuscitation in family presence, as actions involving all three groups can affect the others. Family presence during resuscitation can have important psychological, ethical and clinical implications for the patient, family members and healthcare professionals. During pediatric resuscitation, family presence plays a vital role in psychological recovery. When family members have the opportunity to support each other, emotional bonds are strengthened and coping mechanisms are developed. Family presence always requires a balance. Health professionals should aim to achieve the best outcomes by carefully balancing the emotional needs of family members with clinical requirements. It can be argued that children and family members will benefit from family presence during resuscitation in cardiac arrest and other life-threatening situations. Although family presence during resuscitation is considered to be a right that all patients and their families should have, it is thought that this situation will increase the satisfaction levels of both care providers and care recipients, ensure that the family is an active part of the care and improve the quality of health care provided to the healthy/patient individual.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Children are not mini-adults: a comprehensive review of paediatric uniqueness in clinical care

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ABSTRACT

The physiological, pharmacological, immunological, and psychological uniqueness of paediatric patients necessitates specialized approaches to their medical care. This article comprehensively examines the fundamental differences between children and adults across multiple domains of clinical practice, emphasizing why children cannot be treated simply as "mini-adults". Historical examples, such as the gray baby syndrome resulting from inappropriate chloramphenicol dosing in neonates due to their immature glucuronidation capacity, underscore the potentially fatal consequences of applying adult therapeutic paradigms to pediatric populations. The developmental physiology, pharmacological considerations, immune system development, surgical challenges, psychological factors, diagnostic approaches, therapeutic adaptations, ethical considerations, and long-term implications of paediatric care have been systematically explored. By synthesizing current evidence and expert perspectives, this review provides healthcare professionals with essential insights into the specialized knowledge required for optimal paediatric care. The recognition of these fundamental differences is crucial for ensuring safe, effective, and developmentally appropriate healthcare delivery to paediatric populations.

Keywords: Paediatric medicine, developmental physiology, pharmacokinetics, paediatric surgery, paediatric ethics, child development

INTRODUCTION

The adage that "children are not simply small adults" has become a cornerstone principle in paediatric medicine, yet its full implications are often inadequately appreciated in clinical practice and healthcare systems design. Historically, medical approaches for children were frequently downscaled versions of adult protocols, with minimal adjustments beyond weight-based calculations.[1] This simplistic approach has led to numerous adverse outcomes, therapeutic failures, and missed opportunities for optimal intervention during critical developmental periods.

The evolution of paediatric medicine as a distinct specialty began in earnest in the late 19th and early 20th centuries, with pioneers like Abraham Jacobi advocating for specialized approaches to childhood disease.[2] However, it was not until the latter half of the 20th century that systematic research began to elucidate the profound physiological, pharmacological,[3] and psychological[4,5] differences that distinguish paediatric patients across developmental stages.[6] The recognition of these differences has driven the development of specialized paediatric training, dedicated children's hospitals, paediatric drug formulations, age-appropriate diagnostic approaches, and unique ethical frameworks.

The economic and societal impact of paediatric-specific approaches to healthcare cannot be overstated. Interventions during childhood have the potential to influence health trajectories across the entire lifespan, making paediatric healthcare both a compassionate imperative and a sound investment in population health.[7,8] Conversely, failure to account for paediatric uniqueness can result in immediate adverse outcomes and contribute to lifelong health disparities and chronic disease burden.

METHODS

This review was designed to synthesize and critically analyze current evidence regarding the fundamental physiological, pharmacological, and clinical differences between pediatric and adult patient populations. Given the multidisciplinary nature of pediatric uniqueness spanning developmental biology, clinical pharmacology, surgical specialties, and

healthcare ethics, a narrative review methodology was selected to enable thematic synthesis across diverse research domains and publication types. Primary searches were performed in PubMed and Google Scholar, supplemented by targeted searches using general search engines to capture gray literature and professional guidelines.

The search strategy employed a combination of controlled vocabulary terms and free-text keywords encompassing the terms related to pediatric medicine, developmental physiology, pharmacokinetics, pediatric surgery, and child development. The selection criteria encompassed original research articles, systematic reviews, meta-analyses, clinical guidelines, and seminal texts that addressed physiological, pharmacological, immunological, psychological, surgical, diagnostic, ethical, or therapeutic aspects unique to pediatric populations. Particular emphasis was placed on studies that directly compared pediatric and adult populations or demonstrated age-dependent clinical phenomena. Historical case studies and landmark clinical observations that shaped contemporary understanding of pediatric uniqueness were also included to provide contextual perspective.

DEVELOPMENTAL PHYSIOLOGY: FUNDAMENTAL DIFFERENCES

Growth and Development Trajectories

Human development follows non-linear trajectories characterized by periods of rapid growth and maturation interspersed with relative stability. These patterns vary by organ system and developmental domain, creating "critical periods" during which environmental influences, including medical interventions, may have disproportionate and lasting impacts[9] (**Figure 1**).

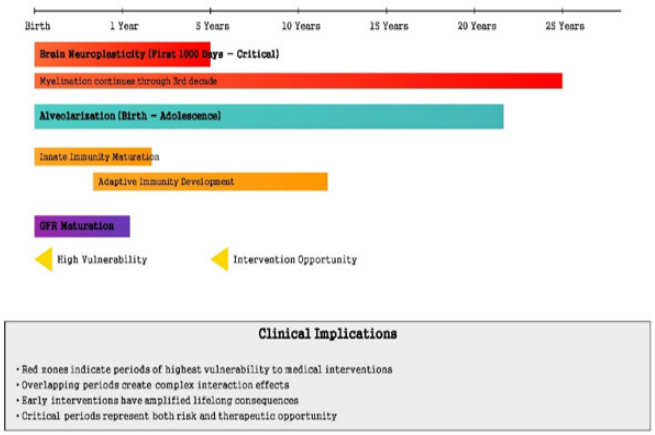

Figure 1. Critical periods in pediatric development

Critical periods represent windows of both vulnerability and opportunity. During brain development, for example, the first 1.000 days of life feature extraordinary neuroplasticity (the brain's ability to reorganize and form new connections), with more than 1 million new neural connections forming every second.[10] Nutritional deficiencies, toxin exposures, or inadequate stimulation during this period can have permanent effects on cognitive development that may be resistant to later intervention. Similarly, pulmonary development continues throughout childhood, with alveolarization continuing through adolescence, creating extended periods of vulnerability to respiratory insults.[11]

The practice of "per kilogram" dosing in paediatrics, while an improvement over one-size-fits-all approaches, remains insufficient to account for the complex physiological scaling that occurs throughout development. Allometric scaling principles (mathematical relationships that describe how biological processes change with body size) demonstrate that metabolic processes do not scale linearly with body weight but rather follow power functions[12] (**Figure 2**). This principle helps explain why simple weight-based extrapolations from adult medicine frequently fail to provide optimal paediatric care.

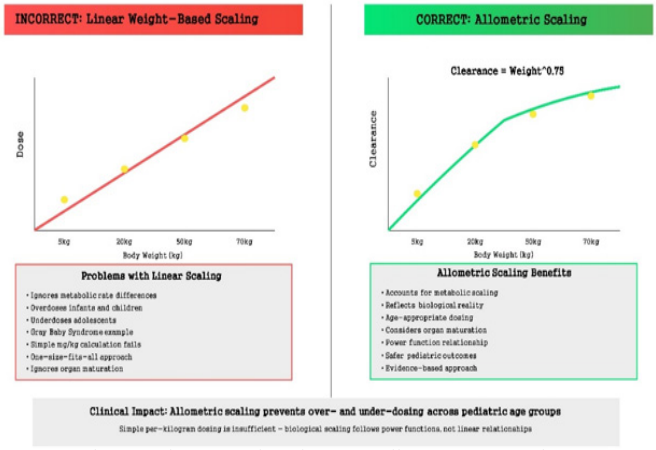

Figure 2. Pharmacokinetic scaling: linear vs. allometric approaches

Organ System Maturation

Neurological development and blood-brain barrier: The blood-brain barrier (BBB), a protective filter that controls what substances can enter the brain from the bloodstream, tightly regulates the movement of ions, molecules, and cells between the bloodstream and the central nervous system and undergoes significant maturation throughout childhood. In neonates, the BBB has greater permeability, potentially allowing greater penetration of medications and toxins into the central nervous system.[13] This increased permeability partially explains why neonates and young infants are more susceptible to the central nervous system effects of medications and why bilirubin encephalopathy (kernicterus or brain damage caused by high levels of bilirubin) remains a concern in neonatal care (**Figure 3**).

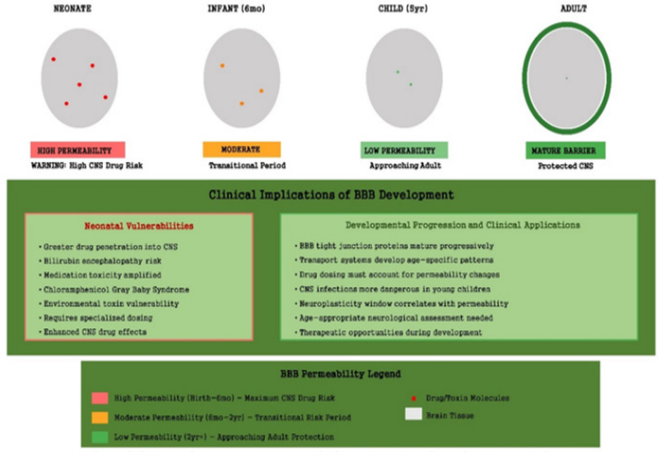

Figure 3. Blood-brain barrier permeability across developmental stages

Neurological development continues throughout childhood and adolescence, with myelination processes extending well into the third decade of life.[14] This prolonged development underlies both the impressive neuroplasticity of the paediatric brain and its vulnerability to injury or disruption.

Hepatic enzyme maturation and drug metabolism: The liver's drug-metabolizing capacity undergoes dramatic changes throughout development, with significant implications for pharmacokinetics (how the body processes medications) and pharmacodynamics (how medications affect the body). Cytochrome P450 (CYP) enzymes, which are liver proteins responsible for breaking down medications, play a central role in drug metabolism, demonstrate variable developmental trajectories. CYP3A7, for example, is highly active in the fetal liver but declines rapidly after birth, while CYP3A4 activity increases progressively throughout the first years of life.[15]

Other important metabolic pathways, including glucuronidation, sulfation, and acetylation, show similarly complex developmental patterns, creating age-dependent variations in drug clearance, half-life, and toxicity profiles. These enzymatic differences help explain why neonates have limited capacity to metabolize medications like chloramphenicol, which can lead to potentially fatal "gray baby" syndrome when adult dosing principles are inappropriately applied to this age group.[16]

Renal function development: Kidney function undergoes substantial maturation throughout infancy and early childhood. Glomerular filtration rate (GFR) at birth is approximately 20 ml/min/1.73 m^2, increasing to 60 ml/min/1.73 m^2 by two weeks of age.[17] This progressive increase in GFR affects the elimination of numerous medications, necessitating age-appropriate dosing adjustments for renally excreted drugs.

Tubular function follows a similar developmental trajectory, with implications for acid-base balance, electrolyte homeostasis, and concentration abilities. The limited concentration capacity of the infant kidney contributes to higher fluid requirements and increased risk of dehydration in young children.[18] These developmental differences in renal physiology necessitate precise fluid management in paediatric care, with careful attention to electrolyte composition and administration rates.

Respiratory, cardiovascular, and thermoregulatory systems: The paediatric respiratory, cardiovascular, and thermoregulatory systems demonstrate fundamental developmental differences from adult counterparts that extend beyond simple scaling (**Table**). These anatomical and physiological variations create unique vulnerabilities in paediatric patients that require specialized knowledge and approaches. The transition from placental-dependent circulation to pulmonary gas exchange represents one of the most dramatic physiologic adaptations in human development.[19] Additionally, the compliant chest wall of infants provides less mechanical advantage for respiration, contributing to increased vulnerability to respiratory fatigue during illness.[20]

Endocrine system development: The hypothalamic-pituitary-gonadal axis demonstrates age-specific activity patterns, with a period of activation during infancy (the "mini-puberty"), followed by childhood quiescence, and subsequent reactivation during adolescence.[21] Growth hormone secretion and action follow developmental patterns that support the characteristic growth velocity changes observed throughout childhood, from rapid infant growth to the relatively stable childhood phase and the pubertal growth spurt.[22] Thyroid function also demonstrates developmental variation, with relatively higher TSH and lower T4 levels in neonates compared to older children and adults.[23]

Limited physiological reserve: Children, particularly infants and young children, possess limited physiological reserves compared to adults, making them vulnerable to rapid decompensation during critical illness. This limited reserve manifests across multiple systems such as glycogen stores,[24] fluid compartments and energy expenditure.

PHARMACOLOGICAL CONSIDERATIONS

Pharmacokinetic Differences

Pharmacokinetic parameters, absorption, distribution, metabolism, and excretion, demonstrate significant age-dependent variations throughout childhood,[25] necessitating specialized approaches to paediatric pharmacotherapy, with absorption being particularly affected by developmental factors including relatively higher gastric pH in neonates and young infants (which gradually decreases to adult values by approximately age 2), affecting ionization and absorption of pH-dependent medications; delayed and more variable gastric emptying in neonates and young infants,[26] leading

Table. Key physiological differences between pediatric and adult patients

Physiological system	Pediatric characteristics	Adult characteristics
Respiratory system	Higher oxygen consumption, smaller functional residual capacity, obligate nasal breathing until 4-6 months, funnel-shaped trachea, anterior larynx	Lower oxygen consumption, larger functional residual capacity, oral breathing capability, cylindrical trachea
Cardiovascular system	Rate-dependent cardiac output, higher baseline heart rates (120-160 bpm in neonates), fetal shunt closure after birth	Greater stroke volume reserve, lower baseline heart rates (60-100 bpm), matured circulation
Blood pressure	Age-dependent norms (e.g., newborn: 65-95/30-60 mmHg; 1-year-old: 90-105/55-70 mmHg), requires age/height/sex-specific percentiles for interpretation	Adult norms (120/80 mmHg), standard percentiles for hypertension classification
Thermoregulation	Larger surface area to body-mass ratio, brown adipose tissue for non-shivering thermogenesis, immature hypothalamic control	Smaller surface area to body mass ratio, developed shivering response, mature hypothalamic control
Renal function	GFR at birth ~20 ml/min/1.73m^2, reaching adult values by 1-2 years, limited concentration capacity	GFR ~120 ml/min/1.73m^2, mature concentration capacity

to less predictable plasma concentrations following oral administration; age-related differences in intestinal motility and transit time influencing medications dependent on specific intestinal regions for optimal uptake; and thinner stratum corneum in neonates and young infants, potentially causing enhanced absorption of topically applied medications with increased risk of systemic toxicity—all of which highlight the challenges of oral medication administration in paediatric patients and explain why certain formulations may demonstrate age-dependent bioavailability.

Metabolism: Enzyme Systems Development Timeline

The cytochrome P450 enzyme system and phase II conjugation pathways demonstrate complex developmental trajectories throughout childhood with significant implications for paediatric medication management. CYP enzymes follow isoform-specific maturation patterns, with CYP3A7 predominating in fetal and neonatal life while CYP3A4 activity progressively increases throughout infancy; CYP2D6 and CYP2C9 activity reach adult levels by approximately 1 year of age, while CYP1A2 maturation extends into early childhood. Similarly, conjugation pathways (glucuronidation, sulfation, and acetylation) show age-dependent activity, with glucuronidation capacity being particularly limited in neonates, affecting the metabolism of medications like morphine and acetaminophen.[15] Additionally, the combination of developmental changes in intestinal and hepatic enzyme activity contributes to age-dependent variations in oral bioavailability for medications subject to significant first-pass metabolism, explaining why certain medications require higher weight-adjusted doses in older children (due to enhanced clearance) while others necessitate dosage reduction in neonates and young infants (due to limited metabolic capacity).

Excretion Pathways Maturation

Renal excretion, the primary elimination pathway for many medications and their metabolites, undergoes significant maturation throughout early childhood, characterized by progressive increase in GFR throughout infancy, which affects the clearance of renally eliminated medications and necessitates age-appropriate dosing adjustments; renal tubular functions (secretion and reabsorption) that mature at different rates than glomerular filtration, creating age-specific patterns of drug elimination for medications dependent on active tubular processes; and increasing proportion of cardiac output directed to the kidneys throughout early childhood, contributing to enhanced renal drug clearance—all of which necessitate careful consideration of dosing intervals for renally eliminated medications, with potential for drug accumulation and toxicity when adult dosing regimens are inappropriately applied to young children.

Pharmacodynamic Considerations

Paediatric patients demonstrate important variations in pharmacodynamic responses to medications beyond pharmacokinetic differences, particularly in receptor expression and sensitivity, which undergo significant developmental changes throughout childhood. The density and functionality of β-adrenergic receptors increase throughout childhood, potentially affecting responses to both endogenous catecholamines and exogenous adrenergic medications.[27] Age-dependent variations in opioid receptor expression and function contribute to different analgesic requirements and side effect profiles across paediatric age groups. Additionally, developmental changes in GABA receptor subunit composition affect responses to benzodiazepines and other GABA-ergic agents, potentially explaining paradoxical reactions observed in some paediatric patients. These receptor-level differences explain why medication effects may vary qualitatively, not just quantitatively, across developmental stages.[28]

Therapeutic Windows That Shift with Age

The therapeutic window, the dosage range that provides efficacy without unacceptable toxicity, demonstrates age-dependent variations for many medications across paediatric populations. For antiepileptic drugs, therapeutic ranges differ between neonates, children, and adults due to differences in plasma protein binding, BBB permeability, and receptor sensitivity.[29] Cardiac medications like digoxin demonstrate age-dependent differences in both therapeutic and toxic serum concentrations, necessitating age-specific target ranges and careful monitoring in paediatric patients.[30] Similarly, the efficacy and adverse effect profiles of many psychotropic medications differ between children and adults, partially explaining why medications effective in adult populations may demonstrate different risk-benefit profiles in paediatric patients. Recognition of these shifting therapeutic windows is essential for safe medication management in paediatric populations, highlighting the limitations of simply applying adult therapeutic ranges to children.

Case Studies of Medication Safety Events from Inappropriate "Scaling Down"

The history of paediatric pharmacotherapy includes numerous examples of adverse outcomes resulting from the inappropriate application of adult dosing paradigms to children:

Chloramphenicol and gray baby syndrome: In the 1950s, the administration of adult-derived chloramphenicol doses to neonates resulted in a potentially fatal toxicity syndrome characterized by cardiovascular collapse, ashen-gray skin discoloration, and metabolic acidosis.[16] This syndrome resulted from the immature glucuronidation capacity (the liver's ability to attach sugar molecules to drugs to help eliminate them from the body) of neonates, leading to drug accumulation and toxicity (**Figure 4**).

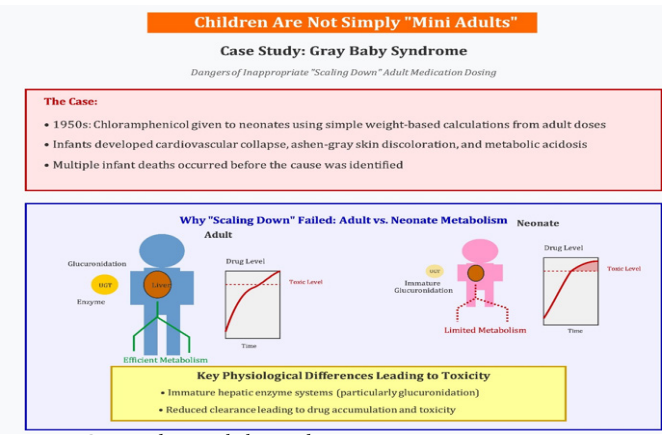

Figure 4. Case study: gray baby syndrome

Sulfanilamide elixir disaster: In 1937, a sulfanilamide elixir formulated with diethylene glycol as a solvent led to more than 100 deaths, many in children. This tragedy highlighted the importance of paediatric-specific formulation considerations and led to significant regulatory reforms.[31]

Propofol infusion syndrome: The use of prolonged propofol infusions for sedation in critically ill children, based on adult protocols, resulted in a fatal syndrome characterized by metabolic acidosis, rhabdomyolysis, and cardiovascular collapse. This syndrome appears more common in children than adults, demonstrating the dangers of uncritical protocol extrapolation.[32]

These historical examples emphasize the potential consequences of treating children simply as "small adults" and underscore the importance of paediatric-specific pharmacotherapy knowledge and research.

IMMUNE SYSTEM DEVELOPMENT AND RESPONSE

Ontogeny of the Immune System

The immune system undergoes complex developmental processes throughout childhood with important implications for disease susceptibility, vaccine responses, and inflammatory conditions. Components of innate immunity follow variable developmental trajectories, with neutrophil mobilization, chemotaxis, and bactericidal functions showing relative impairment in neonates, while natural killer cell activity reaches adult levels by early childhood. The newborn adaptive immune system demonstrates Th2 skewing, with progressive development of Th1 responses throughout early childhood, while memory B and T cell populations expand gradually following antigenic exposures, creating age-dependent variations in immunological memory. Additionally, mucosal immune defences, including secretory IgA production and mucosa-associated lymphoid tissue, mature gradually throughout childhood, affecting susceptibility to respiratory and gastrointestinal pathogens. These developmental patterns create age-specific immunological niches that influence both infectious disease susceptibility and responses to immunomodulatory therapies.

Vaccination Responses Across Developmental Stages

Vaccine immunogenicity and efficacy demonstrate important age-dependent variations across paediatric populations. The neonatal immune system demonstrates distinctive responses to vaccination, with certain vaccines (e.g., BCG, hepatitis B) eliciting protective immunity while others show limited effectiveness in this age group. Transplacentally acquired maternal antibodies may interfere with infant vaccine responses, contributing to the need for multiple-dose primary series for many vaccines. Additionally, adolescence represents another distinctive immunological niche, with implications for vaccines targeting sexually transmitted infections (e.g., HPV) and diseases with changing epidemiological patterns (e.g., meningococcal disease). These developmental variations in vaccine responses have shaped immunization schedules worldwide and highlight the importance of age-appropriate vaccination strategies rather than simple adult vaccine adaptation.

PAEDIATRIC SURGICAL CONSIDERATIONS: BEYOND SIZE ALONE

Spectrum of Congenital Malformations Requiring Unique Surgical Expertise

Paediatric surgery encompasses a spectrum of congenital anomalies without adult counterparts, requiring specialized knowledge beyond simple anatomical scaling. Conditions like esophageal atresia with tracheoesophageal fistula, anorectal malformations, and biliary atresia represent anatomical variations not encountered in adult surgical practice. Disorders of embryological development, such as bladder exstrophy, gastroschisis, and conjoined twins, require a comprehensive understanding of embryology and reconstructive principles. Many congenital anomalies affect multiple organ systems, necessitating multidisciplinary approaches and consideration of developmental implications, for example, congenital diaphragmatic hernia affects not only diaphragmatic integrity but also lung development, cardiovascular function, and sometimes neurological outcomes. These complex conditions require paediatric surgical specialists with specific training and experience beyond general surgical principles applied to smaller patients.

Technical Challenges Specific to Paediatric Surgery: Beyond Simple Miniaturization

The smaller scale of paediatric anatomy necessitates specialized instrumentation, magnification techniques, and refined tissue handling, particularly in neonatal and infant surgery. This demanding field requires paediatric-specific surgical instruments, including finer forceps, smaller retractors, and specialized vascular clamps, all essential for safe and effective procedures in small children. Paediatric tissues also demonstrate different tensile strengths and healing characteristics, necessitating appropriate suture selection and handling techniques to prevent tissue damage. The confined operative field in small children creates visualization challenges, particularly in deep anatomical regions like the pelvis or retroperitoneum, requiring specialized approaches to exposure and access.

Neonatal and infant tissues demonstrate increased fragility, necessitating exceptionally gentle handling techniques and appropriate instrument selection to prevent iatrogenic injury. Children typically demonstrate more rapid healing than adults, with different scarring patterns and greater potential for hypertrophic scar formation, particularly during adolescent growth spurts. Perhaps most importantly, surgical interventions must account for future growth potential, with techniques that accommodate tissue expansion and minimize growth restriction—a principle particularly important in orthopedic, plastic, and urological procedures. Understanding these tissue characteristics is essential for optimal surgical outcomes in paediatric patients and represents a fundamental aspect of specialized paediatric surgical training.

Anesthetic management in paediatric patients involves considerations that go well beyond weight-based medication dosing adjustments. The paediatric airway differs anatomically from adults, with a more anterior larynx, shorter trachea, and funnel-shaped subglottis, creating distinctive challenges for intubation and airway maintenance during surgery. Children lose heat more rapidly during surgery due to their larger surface area to volume ratio, necessitating careful attention to temperature monitoring and conservation strategies throughout the perioperative period. Fluid and electrolyte management requires exceptional precision during paediatric procedures, with significantly smaller margins for error in volume and electrolyte administration than typically encountered in adult practice. Blood volume calculations must be precise, with even small miscalculations potentially leading to significant hemodynamic consequences.

Decision-making for Procedures with Lifelong Implications

Paediatric surgical decision-making must consider the long-term impact of interventions on a developing child, with consequences that may extend decades into adulthood. The optimal timing for surgical intervention balances immediate needs against developmental considerations—for example, early closure of cleft palate facilitates normal speech development, while delayed reconstruction of certain orthopedic deformities may allow for growth completion. Surgical procedures involving growth plates, endocrine organs, or structures subject to significant remodeling must consider long-term growth implications, not just immediate correction.

The long-term consequences of paediatric surgical interventions are powerfully illustrated by case examples that demonstrate how complications can manifest years or even decades later. As described by Das,[33] a patient who underwent choledochal cyst surgery at age 3 later presented with abdominal pain and jaundice at age 17 due to an anastomotic stricture near the porta hepatis—a complex surgical problem that would challenge even experienced general surgeons. In another striking case, a patient operated on at 2 days of age for jejunal atresia with meconium peritonitis returned 22 years later with severe complications. This patient had developed cholelithiasis at age 10 and underwent cholecystectomy performed by a general surgeon, who noted intense intestinal adhesions during the procedure. Multiple surgical complications followed, including intestinal injury, fecal fistula development, and failed repair attempts, leaving the patient with a chronic fistula for 10 years before successful surgical intervention. These cases highlight how the legacy of paediatric surgical conditions and their management can extend well into adulthood, underscoring the need for specialized paediatric surgical expertise and long-term follow-up.

These decision-making complexities highlight the ethical dimensions of paediatric surgery and the importance of involving families in shared decision-making that considers both immediate outcomes and long-term quality of life. Paediatric surgeons bear a unique responsibility not only for the immediate technical success of procedures but also for the lifelong implications of their interventions on a developing child's future health, function, and well-being. The unique challenges of paediatric surgery necessitate specific training and expertise, including dedicated fellowship programs and specialized credentials.

Multidisciplinary Approach Requirements

Paediatric surgeons frequently collaborate with developmental specialists to assess the impact of surgical interventions on developmental trajectories and to implement appropriate supportive interventions. This integration ensures that surgical management decisions consider not only anatomical correction but also cognitive, motor, and social developmental implications. Many paediatric surgical conditions require longitudinal follow-up throughout childhood and adolescence to monitor growth, function, and potential need for additional interventions as development progresses—creating care continuity requirements that may span decades rather than months.

Paediatric surgical patients benefit from specialized nursing care and rehabilitation services that address developmental needs alongside recovery from surgical intervention. Paediatric surgical nurses require expertise not only in technical aspects of postoperative care but also in age-appropriate communication, pain assessment in non-verbal children, and recognition of developmental variations in physiological responses. Similarly, paediatric rehabilitation specialists develop therapeutic approaches that account for ongoing neurological and musculoskeletal development while addressing surgical recovery needs.

This comprehensive multidisciplinary approach distinguishes paediatric surgical practice from adult models and highlights the importance of specialized children's hospitals and paediatric surgical training programs in optimizing outcomes for these complex patients.

PSYCHOLOGICAL AND NEUROCOGNITIVE UNIQUENESS

Cognitive Development Stages and Clinical Implications

Cognitive development progresses through established stages throughout childhood with significant implications for paediatric healthcare delivery. During the sensorimotor stage (birth to 2 years), infants comprehend experiences primarily through sensory input and motor actions, necessitating healthcare approaches that emphasize soothing sensory experiences and parental presence. The preoperational stage (2-7 years) is characterized by emerging symbolic thought but persistent egocentrism, requiring concrete explanations and attention to illness causality misconceptions. As children enter the concrete operational stage (7-11 years), their increased logical thinking capabilities support more detailed medical discussions, though still benefiting from visual aids and concrete examples. Adolescents in the formal operational stage (11+ years) develop abstract reasoning that facilitates more sophisticated treatment discussions, though decision-making capacity continues to mature.[34] These developmental variations necessitate stage-appropriate communication strategies rather than modified adult approaches (**Figure 5**).

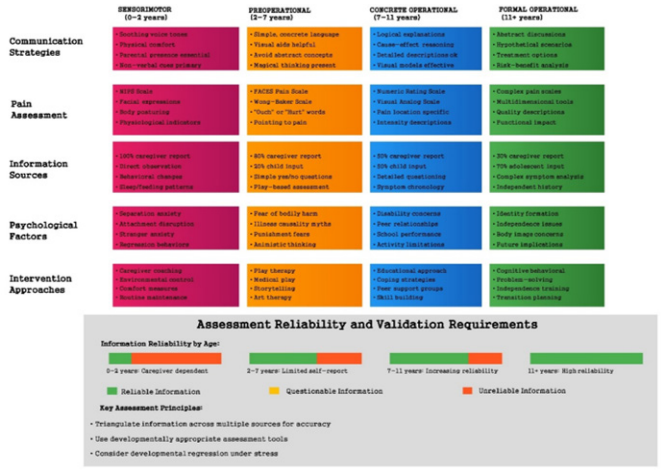

Figure 5. Pediatric communication assessment matrix by developmental stage

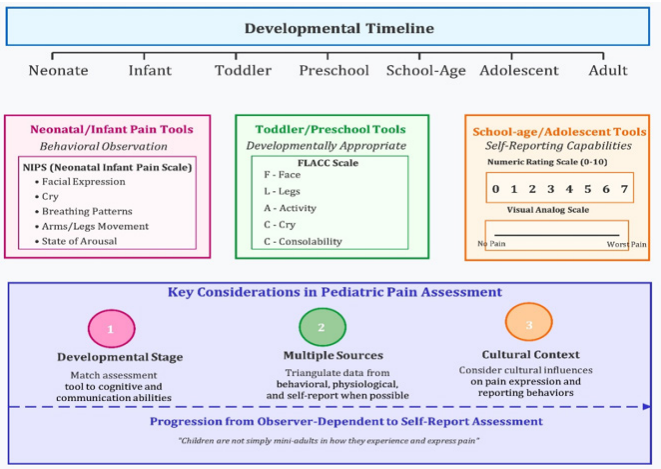

Figure 6. Pain assessment tools across developmental stages

Communication Challenges in Clinical Assessment

Paediatric communication abilities present distinct challenges for symptom assessment and clinical evaluation. Pre-verbal children communicate discomfort through nonverbal indicators including facial expressions, body posturing, and physiological changes, requiring observational assessment protocols. Young children typically employ concrete, limited vocabulary for symptom description, often with idiosyncratic terminology and imprecise pain localization. Heightened suggestibility in paediatric populations may affect symptom report reliability, particularly when leading questions are employed. Children with developmental language disorders present additional assessment complexities requiring modified communication strategies. These developmental communication variations necessitate specialized assessment instruments and interpretation frameworks specifically designed for paediatric populations.

Developmental Aspects of Pain Perception and Expression

Pain perception and expression demonstrate significant developmental variation throughout childhood. Nociceptive system development occurs early, with documented pain responses in premature infants, contradicting historical assumptions about limited neonatal pain perception. Pain expression behaviors vary across developmental stages, from generalized distress responses in infants to increasingly differentiated verbal descriptions in older children.[35] Pain memory formation influences subsequent healthcare experiences, potentially manifesting as anticipatory distress. Cultural and familial contexts significantly shape pain expression patterns,[36] creating heterogeneous pain communication styles requiring recognition in paediatric assessment protocols. These developmental considerations necessitate age-appropriate pain assessment instruments and management approaches specifically validated for paediatric populations (**Figure 6**).

Developmental Variation in Psychological Impact of Illness

The psychological impact of illness and hospitalization demonstrates significant developmental variation.[37,38] For infants and toddlers, caregiver separation constitutes the primary psychological stressor, potentially disrupting attachment security and developmental progression. Preschool children commonly experience fear of bodily harm and separation anxiety, often manifesting as behavioral regression. School-age children typically express concerns regarding physical disability and peer relationship disruption, potentially presenting as withdrawal or academic difficulties. Adolescents face challenges to emerging independence and body image, sometimes responding with treatment non-adherence or identity disturbance. These developmental variations in psychological impact necessitate age-appropriate psychosocial interventions tailored to specific developmental concerns rather than generic approaches.

DIAGNOSTIC CHALLENGES

Laboratory Reference Ranges: Why Adult Values Don't Apply

Paediatric laboratory values demonstrate age-dependent variations that reflect developmental physiology rather than pathology.[39,40]

Hematological parameters: Red blood cell indices, white blood cell counts, and platelet counts demonstrate substantial age-dependent variations (**Figure 7**).

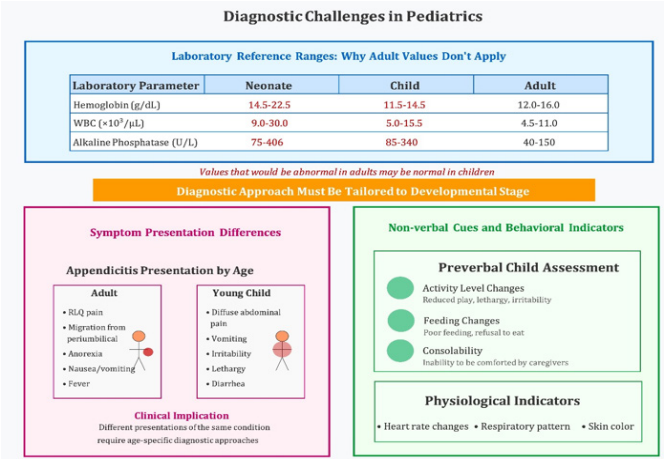

Figure 7. Diagnostic challenges in pediatrics

Chemistry values: Electrolytes, renal function markers, liver enzymes, and metabolic parameters demonstrate age-specific reference ranges that reflect developmental physiology. For example, alkaline phosphatase levels are substantially higher in growing children due to bone turnover, while creatinine values reflect developing muscle mass and renal function.

Endocrine parameters: Hormone levels demonstrate complex developmental patterns throughout childhood and adolescence, necessitating age, sex, and pubertal stage-specific reference ranges for accurate interpretation.

The use of adult-derived reference ranges in paediatric populations can lead to misdiagnosis, unnecessary testing, and inappropriate interventions, highlighting the importance of age-specific laboratory interpretation in paediatric practice.

Imaging Considerations and Radiation Sensitivity

Paediatric imaging involves important considerations beyond simple technical adjustments:

Radiation sensitivity: Children demonstrate greater radiosensitivity than adults, with higher lifetime risk of radiation-induced malignancy, such as cancer,77i due to increased tissue radiosensitivity and longer life expectancy.[41]

ALARA principle: The "as low as reasonably achievable" principle takes on heightened importance in paediatric imaging, driving the development of paediatric-specific imaging protocols, equipment settings, and technological innovations to minimize radiation exposure.[42]

Developmental variations in normal imaging appearance: Normal anatomical structures and physiological processes demonstrate age-dependent variations on imaging studies, necessitating specialized knowledge for accurate interpretation.

These considerations influence paediatric imaging algorithms and highlight why adult imaging approaches cannot be simply transferred to paediatric populations without modification.

Limited Self-reporting Capabilities: Dependence on Observation and Caregiver Reports

Paediatric diagnostic methodology demonstrates fundamental epistemological differences from adult assessment paradigms, primarily due to developmental limitations in self-reporting capabilities:

Information triangulation requirements: While adult assessment typically relies predominantly on patient self-report supplemented by objective measures, paediatric assessment necessitates systematic triangulation across multiple informants. This multi-informant approach represents a structural diagnostic difference rather than merely an adaptation of adult assessment protocols.

Developmental variability in reporting accuracy: Unlike adult populations where reporting accuracy primarily varies with cognitive status, paediatric reporting accuracy demonstrates significant developmental trajectory dependence. Children under 5 years demonstrate limited ability to accurately report temporal sequences, symptom duration, or intensity gradations. School-age children show developmental progression in symptom discrimination but persistent difficulties with symptom attribution and intensity scaling. These developmental constraints represent qualitative rather than quantitative reporting differences compared to adult populations.

Hierarchical information weighting: Paediatric diagnostic models require developmentally-informed hierarchical weighting of information sources, with observational data holding greater diagnostic validity in younger children and self-report gaining increased weighting with developmental progression. This contrasts with adult assessment wherein self-report typically maintains primary diagnostic priority except in cases of cognitive impairment. Furthermore, parental psychopathology, family functioning, and parental healthcare experiences significantly influence symptom reporting in paediatric contexts, creating potential assessment biases without direct adult assessment parallels.

Non-verbal Assessment Parameters: Comparative Analysis of Paediatric vs. Adult Indicators

Non-verbal assessment parameters in paediatric populations demonstrate both quantitative and qualitative differences from adult counterparts:

Physiological parameter interpretation: Paediatric physiological indicators require age-specific interpretation frameworks due to developmental variations in baseline parameters and stress responses. Unlike adults, where tachycardia represents a relatively specific stress indicator, paediatric heart rate interpretation requires consideration of developmental baselines, with resting heart rates ranging from 120-160 bpm in infants to 60-100 bpm in adolescents. Additionally, the physiological stress response demonstrates developmental differences, with infants showing shorter cortisol elevation durations but more pronounced cardiovascular reactivity compared to adults.

Behavioural repertoire differences: The behavioural manifestation of illness and distress in paediatric populations involves a developmentally distinct repertoire compared to adults. While adults typically demonstrate illness behaviour through activity restriction and healthcare-seeking, paediatric illness behaviour commonly manifests through regression to earlier developmental functioning, changes in play complexity, and alterations in social engagement patterns. These behavioural indicators lack direct adult parallels and require developmental expertise for accurate interpretation.

Ontogeny of facial expression: Facial expression coding systems for paediatric assessment (e.g., Neonatal Facial Coding System[43]) recognize developmentally distinct facial action patterns not present in adult facial coding systems. Neonatal and infant facial expressions demonstrate more global activation patterns and fewer discriminative features compared to adult expressions, necessitating specialized coding systems rather than downward extensions of adult facial analysis.

Motor development considerations: Postural assessment in paediatric populations requires integration with motor development trajectories, not relevant to adult assessment. Abnormal posturing must be distinguished from transitional

motor patterns characteristic of typical development (e.g., asymmetric tonic neck reflex, obligatory pronation in early reaching) without adult parallels. This developmental context creates a qualitatively different interpretive framework for motor and postural assessment compared to adult populations.

These fundamental differences in assessment parameters, information sources, and developmental considerations highlight the necessity of specialized paediatric assessment frameworks rather than simply modified adult approaches. The developmental constraints on self-reporting combined with the distinct non-verbal manifestations of illness create unique diagnostic challenges that require specialized paediatric expertise for accurate clinical assessment and management.

ETHICAL AND LEGAL CONSIDERATIONS

Decision-Making Frameworks Unique to Paediatrics

Paediatric ethics involves distinctive considerations related to developing autonomy and parental authority:

Parental consent requirements and limitations: Parents or legal guardians generally hold decision-making authority for children, with boundaries established by concepts of the child's best interest and state child protection frameworks.

Developmentally appropriate assent for children ≥7 years: Children develop decision-making capacity gradually, with assent (affirmative agreement to participate) increasingly sought as children mature, even when formal legal authority remains with parents.

Evolving capacity assessment: Evaluation of children's decision-making capacity considers not only age but also individual maturity, complexity of the decision, and potential consequences of various options.

Navigating conflicts between child and parental preferences: Approaches to managing disagreement between children's expressed preferences and parental decisions become increasingly nuanced as children develop greater decision-making capacity, particularly for adolescents approaching legal majority.

These decision-making frameworks highlight the developmental context of paediatric ethics and the limitations of adult-oriented autonomy models when applied to children at various developmental stages.

Life-altering Treatment Decisions and Their Ethical Dimensions

Certain paediatric treatment decisions involve particularly complex ethical considerations due to their lifelong implications:

Ablative surgeries with permanent consequences: Procedures that permanently alter anatomy or function (e.g., organ removal, fertility-affecting interventions) raise unique ethical questions when performed on children who cannot provide informed consent.

Quality of life considerations for chronic conditions: Decision-making for children with life-limiting or severely debilitating conditions must consider quality of life alongside survival, with recognition that quality assessments may differ between children, parents, and providers.

Weighing immediate vs. long-term implications: Decisions with diverging short-term and long-term implications create complex ethical considerations. For example, clean intermittent catheterization versus permanent urinary diversion procedures in spina bifida involve tradeoffs between immediate quality of life and long-term complications.

Palliative care and end-of-life decision-making: End-of-life decision-making for children raises distinctive ethical questions regarding the roles of parents, providers, ethics committees, and courts in determining the best interests of children who cannot express their own values.

These ethical dimensions highlight why paediatric decision-making frameworks must consider developmental context, parental authority, and the unique vulnerabilities and capabilities of children at different developmental stages.

Life Expectancy Considerations in Treatment Decisions

Children's longer life expectancy influences ethical considerations regarding treatment benefits and burdens:

Longer duration of benefit: Successful interventions in childhood may provide benefit over many decades, potentially justifying higher initial costs or risks than might be acceptable in late adulthood.

Cumulative treatment burden: Conversely, treatments with cumulative toxicity or complications may have greater lifetime impact when initiated in childhood, necessitating careful consideration of long-term effects.

Evolving treatment landscape: Children with chronic conditions will experience evolving treatment options throughout their lifetime, creating uncertainty about whether current definitive interventions will remain optimal as new options emerge.

Unknown very long-term outcomes: Many paediatric interventions lack very long-term outcome data (e.g., 30+ years), creating ethical challenges regarding decision-making with incomplete information.

These life expectancy considerations highlight an important dimension of paediatric decision-making that has limited parallel in adult medical ethics.

LIFE COURSE IMPLICATIONS

Transition to Adult Care Challenges

The transition from paediatric to adult healthcare systems represents a vulnerable period requiring specialized

approaches that address multiple interconnected domains. Effective transition necessitates structured knowledge transfer between healthcare systems with fundamentally different care models, documentation practices, and specialty structures while simultaneously supporting the progressive development of disease knowledge, self-management skills, and healthcare navigation capabilities throughout adolescence and young adulthood. Successful transition programs typically incorporate systems-level approaches to ensure continuity of care, including transition coordinators who bridge communication gaps, overlap clinics that allow relationship building with adult providers before full transfer, and condition-specific transition protocols that address unique needs of different patient populations. These multifaceted transition challenges highlight the problematic nature of rigid age-based healthcare divisions and underscore the importance of developmental rather than strictly chronological approaches to healthcare transition planning and implementation.

FUTURE DIRECTIONS

Precision Medicine Applications in Paediatrics

Precision medicine applications in paediatrics necessitate distinct considerations extending beyond approaches appropriate for adult populations. Gene expression follows dynamic developmental patterns, creating age-specific genomic signatures and therapeutic targets that demand longitudinal rather than cross-sectional analysis frameworks. Unlike adult precision medicine, paediatric applications must carefully evaluate potential impacts on growth trajectories, developmental milestones, and pubertal progression when selecting targeted therapies. The timing of genomically targeted interventions[44] in early developmental windows may produce amplified effects, both beneficial and adverse, throughout the lifespan, creating unique risk-benefit calculations not encountered in adult precision medicine. Additionally, biomarkers fundamental to precision medicine approaches require paediatric-specific validation processes, as biomarkers validated in adult populations frequently demonstrate substantially different performance characteristics across developmental stages. These developmental dimensions of precision medicine underscore why paediatric genomic medicine require specialized approaches rather than simple adaptation of adult precision medicine paradigms.

Technology Adaptation for Paediatric Care

Emerging technologies in healthcare require fundamental developmental adaptations rather than simple downsizing for effective paediatric application. Digital health interventions must address distinctive paediatric considerations including developmental appropriateness across cognitive stages, family-centered engagement strategies, educational setting integration, and enhanced privacy protections for vulnerable populations. Medical device development faces unique challenges in paediatric contexts including smaller market incentives, accommodation for physical growth, and age-specific human factors requirements—necessitating specialized regulatory pathways and development incentives. Artificial intelligence applications for paediatric populations must contend with the complex developmental dynamics of both normal variation and pathological conditions, creating additional algorithmic complexity compared to adult applications where baseline states remain relatively stable. Similarly, paediatric telehealth requires specific adaptations including structured approaches to three-way communication involving caregivers, modifications to developmental assessment techniques for remote delivery, and integration frameworks for schools and childcare settings. These multifaceted adaptation requirements demonstrate why emerging healthcare technologies demand fundamental reconsideration based on developmental principles rather than simple miniaturization for paediatric implementation.

CONCLUSION

The evidence presented throughout this comprehensive review demonstrates conclusively that the principle "children are not simply small adults" extends far beyond a mere aphorism to represent a fundamental scientific reality with profound implications for healthcare delivery across molecular biology, systems physiology, pharmacology, psychology, ethics, and healthcare organization. Several critical themes emerge: developmental trajectories create uniquely paediatric physiological states requiring specialized knowledge; childhood healthcare interventions have amplified lifelong implications creating both extraordinary opportunity and significant risk; simplistic scaling approaches consistently fail across all domains of paediatric care; specialized healthcare structures are essential rather than merely preferable; and emerging healthcare technologies may amplify both opportunities and risks if not specifically adapted for developmental considerations. These findings necessitate specific policy frameworks supporting paediatric research and specialized care; educational approaches that go beyond adapting adult content; research methodologies addressing unique paediatric challenges; and clinical practice standards incorporating developmental rather than merely scaled considerations. The scientific basis for specialized paediatric healthcare spans from molecular to societal levels and demands continued investment in paediatric-specific knowledge, research, and healthcare systems to ensure all children receive care optimally suited to their unique developmental needs.

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Referee Evaluation Process

Externally peer-reviewed.

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The authors have no conflicts of interest to declare.

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All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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MHA MEDIHEALTH ACADEMY

Surgery on Children

Review

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The evaluation, diagnosis and management of adnexal torsion in pediatric and adolescent patients

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ABSTRACT

Adnexal torsion is a surgically diagnosed gynecological emergency with 30% of cases occurring in females under the age of 20. The most common ovarian pathologies observed in adolescents with adnexal torsion are benign teratomas and benign functional ovarian cysts. However, in 46% of cases, torsed ovaries are normal, without a mass or cyst. The torsion of malignant ovarian masses is extremely rare in this population. Torsion often presents with sudden-onset, intermittent abdominal pain, nausea and vomiting. It should be noted that there are no sufficient clinical or imaging criteria available, and Doppler ultrasound alone is not a guide to clinical decision-making to confirm the pre-operative diagnosis of adnexal torsion. If ovarian torsion is suspected, prompt intervention with diagnostic laparoscopy is recommended to preserve ovarian and tubal function. In 50% of cases, adnexal torsion is not found during laparoscopy; however, other gynecologic pathologies are identified and treated. When adnexal torsion is detected, detorsion is recommended, regardless of ovarian appearance. The purpose of this review is to guide clinicians regarding the current management and ovarian-sparing surgery of adolescent and pediatric patients with adnexal torsion.

Keywords: Adnexal torsion, adolescent, laparoscopy, ovarian torsion

INTRODUCTION

Adnexal torsion is the rotation of any combination of a normal or pathological ovary, fallopian tube or a paratubal cyst around the infundibulopelvic or utero-ovarian ligaments. It is the fifth most common gynecological emergency. It is estimated that approximately five in every 100.000 females between the ages of 1 and 20 are diagnosed with adnexal torsion.[1] Moreover, females under the age of 20 account for 30% of all adnexal torsion cases.[2] Its incidence increases in girls over the age of ten, as the frequency of physiological and pathological masses increases due to hormonal changes and gonadal growth.[3] Adnexal masses more than 5 centimetres increase the likelihood of torsion.[4] The most common ovarian pathologies in adolescents with adnexal torsion due to ovarian mass are benign functional ovarian cysts and benign teratomas.[5] Malignant ovarian mass torsion is uncommon in this cohort.[3] In contrast to adnexal torsion in adults, 46% of pediatric and adolescent girls experience adnexal torsion involving the ovary without a mass or cyst.[6] Predisposing variables may include a relatively small uterus that provides greater space for the adnexa to spin on its axis, excessive laxity of the pelvic ligaments, or congenitally lengthy ovarian ligaments.[3] Sixty-four percent of torsions occur on the right side due to the presence of the descending colon on the left and the longer right utero-ovarian ligament compared to the left.[7] In the pediatric literature, isolated tubal torsions are rare, with occurrences that are nearly invariably linked to tubal disease, including paratubal cysts.[8] Early diagnosis and treatment are very important for the preservation of ovarian and tubal functions. However, due to non-specific symptoms, diagnosis is not always easy, and difficulties may be encountered in managing the process. If ovarian torsion is suspected, laparoscopy is recommended for diagnostic and therapeutic purposes. In this article, the current literature on the management of pediatric and adolescent patients with ovarian torsion, possible surgical problems and future expectations are reviewed.

METHODS

PubMed, Scopus, Google Scholar, MEDLINE, UpToDate and Cochrane databases were searched for this review. Medical Subject Headings (MeSH) terms for adolescent and pediatric populations up to 1996 were used: “ovarian torsion,” “adnexal torsion,” and “ovarian preservation.” Single case reports, inconsistent articles, and non-English language articles were excluded.

PATHOPHYSIOLOGY

When ovarian torsion occurs, it causes compression of the ovarian arteries, veins and lymphatic vessels. The number and degree of twisting affect the severity of the compression. Venous vessels are subject to greater compression than arterial vessels due to their thinner walls. Therefore, venous drainage is initially impaired. With continued arterial perfusion, the ovary enlarges and becomes oedematous. Then, with further compression, ovarian ischemia, necrosis, haemorrhage and peritonitis begin to develop.[9] However, sepsis is rare.[10]

Chronic adnexal torsion can lead to necrosis, loss of function, amputation of the ovary, pelvic adhesions, pelvic pain, and tubal obstruction.[11] It is unknown how long after symptom onset ovarian necrosis will develop. An observational analysis of 22 pediatric patients with ovarian torsion found no correlation between the time from symptom onset to surgical intervention and ovarian preservation.[12]

DIAGNOSTIC EVALUATION

It is important to keep in mind that there are no radiological or clinical criteria that are adequate to validate the preoperative diagnosis of adnexal torsion when evaluating adolescents who may have it.[13] The most typical clinical sign of torsion is abrupt, intermittent, non-radiating abdominal pain that is accompanied by nausea and vomiting. In 62% and 67% of patients, respectively, nausea and vomiting are recorded.[14] It is reported that nausea and vomiting are more common in pre-menarchal patients.[1] Abdominal tenderness has been reported in 88% of patients with adnexal torsion, and rebound and peritoneal symptoms have been reported in 12-27%.[14,15] An adnexal mass may be palpable.[16] Low grade fever is present in 2% to 20% of patients, and might indicate adnexal necrosis, especially when leucocytosis is present. Most patients present to the hospital within one to three days of pain onset. Infrequent accounts of pelvic pain lasting up to 210 days, however, have been reported in the literature; these could be instances of intermittent torsion.[17]

Transabdominal ultrasonography is the preferred imaging method for the detection of adnexal torsion, with 92% sensitivity and 96% specificity.[18] On ultrasonographic examination, the torsed ovary appears oedematous, large and heterogeneous compared to the other side, and its position may have shifted towards the front of the uterus.[16] Moreover, follicles may appear arranged at the periphery of the ovary due to oedema. This image is also seen in polycystic ovary syndrome, but the central stroma is echogenic; both ovaries have a similar appearance, and the patient has no pain. In addition, if there is a mass in the torsed ovary or tube, it can be visualised ultrasonographically.[19] In a torsed ovary, Doppler flow may be normal, reduced or absent. Doppler flow may be normal because the adnexa is not completely occluded, is intermittently torsed, or because there is collateral blood flow. Therefore, normal Doppler flow does not exclude the diagnosis of torsion. When making an evaluation, both ovaries should be examined and compared.[20] The "whirlpool sign" (a doppler ultrasonographic image) indicating twisting of the vascular peduncle has a sensitivity of 90% or more.[21]

When evaluating a patient for a differential diagnosis of abdominal pain, a computed tomography (CT) scan or magnetic resonance imaging (MRI) scan may often be performed. The results will be similar to those of an ultrasound.[22]

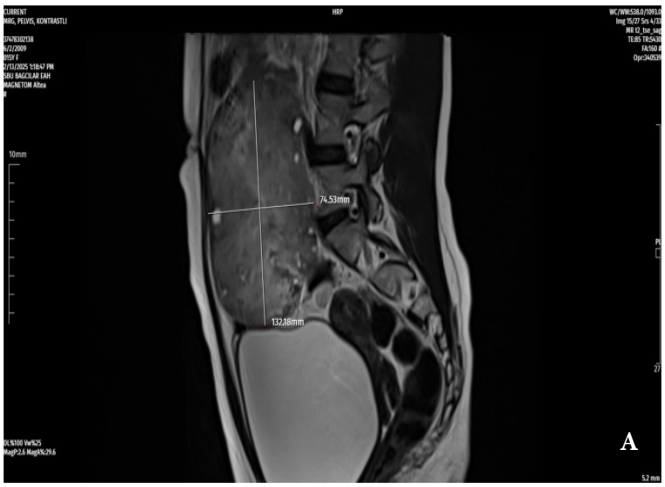
Adnexal torsion is diagnosed surgically.[4] In 50% of the cases with a preliminary diagnosis of adnexal torsion, adnexal torsion may not be detected during laparoscopy.[23] This negative result from laparoscopies is a clinically acceptable outcome considering the significance of ovarian preservation.

In girls around menarche, ruptured ovarian cysts and appendicitis should be kept in mind in the differential diagnosis.

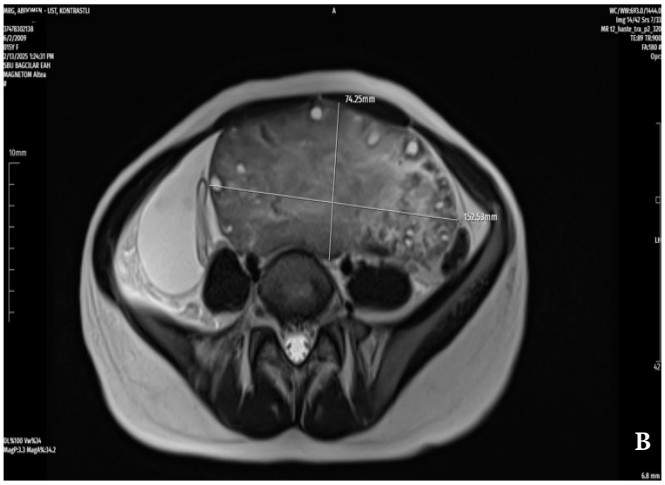
SURGICAL EVALUATION AND MANAGEMENT

Confirming torsion, evaluating ovarian viability, and correcting torsion are the objectives of surgical evaluation. A laparoscopic approach is recommended for surgical evaluation. Intraoperative assistance may be sought from a gynecologist experienced in detorsion and ovarian preservation.[24] Unless a malignant tumour is suspected, a torsed ovary should be considered viable as ovarian necrosis is very rare. There is no effective approach to determine ovarian viability and adequate perfusion during surgery. An enlarged and dark ovary may appear alarming to the surgeon, but it is still most likely viable. This appearance is usually due to congestion. It is best to endeavour to preserve the tube and ovary, accepting the possibility that the tube and ovary may not survive or may need to be removed at a later date. Previously, ovaries with this appearance were thought to be necrotic and non-viable. Because total arterial flow is presumably maintained at least partially in the torsed ovary despite venous and lymphatic congestion, numerous studies have shown that many patients retain ovarian function even after detorsion.[5,25-27] The lightening of the ovary colour after being detorsed is an indication that blood flow has improved. A 15-year-old adolescent patient, who underwent surgery 33 days later because her symptoms were intermittent and whose adnexal torsion diagnosis was made quite late, had normal ovaries on ultrasonographic imaging 2 months after surgery [**Figure 1 (1A,1B,1C,1D)**].

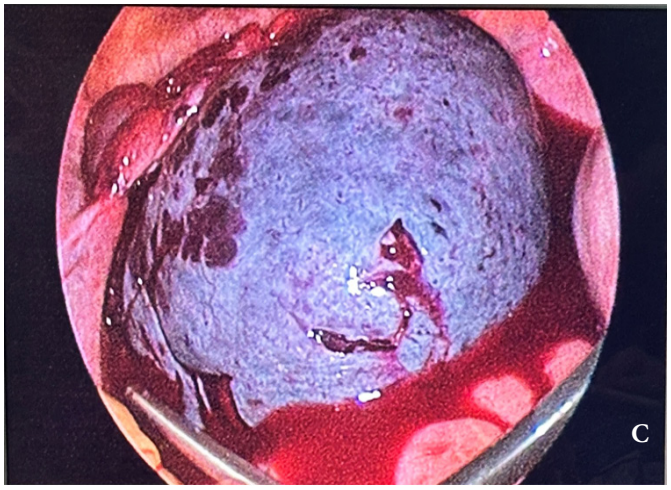
Previously, it was believed that ovarian preservation could lead to haemorrhage, peritonitis, abscess, infection, adhesion formation, or embolism.[28] Nevertheless, there is evidence that detorsion is not linked to these issues.[29] Despite increasing evidence of the safety and benefits of ovarian preservation, oophorectomy rates remain high in non-teaching hospitals.[30] Pediatric surgeons are primarily responsible for managing ovarian torsion in pediatric patients. Gynecologists and pediatric surgeons have different practice patterns, such that gynecologists are more likely than pediatric surgeons to perform ovarian preservation for torsion.[31] Aziz et al.[32] found that paediatric gynecologists performed 94% of ovarian detorsion surgeries, compared to 6% of pediatric surgeons in a single-institution sample of 34 patients.



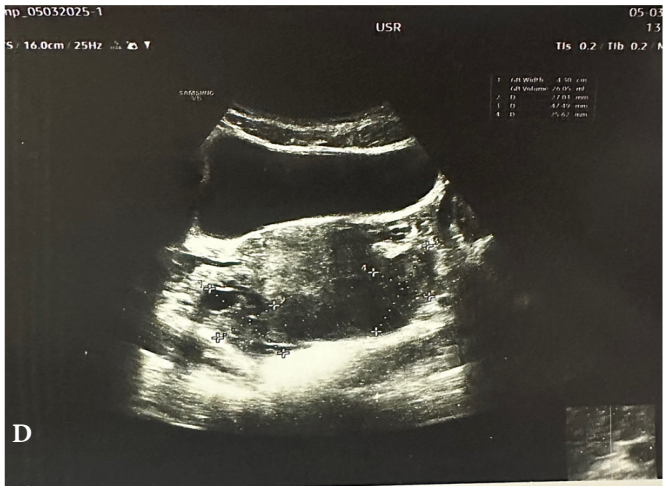
A. Sagittal section of the lesion identified on MRI



B. Transverse section of the lesion identified on MRI



C. Intraoperative laparoscopic image of the adnex rotated 5 times around itself



D. In the patient's second month postoperative evaluation, bilateral ovaries appeared normal with almost equal size on ultrasonography

Figure 1. Preoperative, intraoperative and postoperative images of a 15-year-old adolescent patient who underwent surgery 33 days later because her symptoms were intermittent and whose adnexal torsion diagnosis was made quite late. The patient's preoperative contrast-enhanced magnetic resonance imaging (MRI) revealed a well-circumscribed, T2-weighted, heterogeneously hyperintense, and T1-weighted, heterogeneously hypointense lesion extending from the pelvic inlet to the level of the umbilicus, measuring 152x132x74 mm. The lesion contained multiple millimeter-sized areas in the periphery, which were interpreted as follicles (Photographs are from Evrim Ebru Kovalak's archive).

The true incidence of malignancy in the pediatric population is uncertain, but concern for malignancy is often a driving factor in pursuing oophorectomy.[33] Because the torsed ovary is large and blue-black in colour, it may be difficult to assess the presence of any underlying malignancy.[2] In torsion case series where oophorectomy was performed, malignancy was detected in 0.4-5%.[34,35] Because of the risk of overlooking a hidden cancer, there is no evidence that oophorectomy is superior to detorsion. Oophorectomy should not be performed solely on the pretext of the possibility of malignancy. An oophorectomy needs to be contemplated only in cases where there is unambiguous clinical evidence of a malignancy.

Numerous studies have shown that ovaries with a blue-black colour due to torsion show follicle development on ultrasound follow-up after detorsion. Pathological examination of ovaries that underwent oophorectomy due to presumed complete necrosis has also revealed viable ovarian tissue.[36] Moreover, adult ovarian detorsion and preservation has been associated with successful pregnancies and live deliveries.[37] Since folliculogenesis after ovarian detorsion has been widely documented, ovarian conservation ought to be a top objective for surgery.

A recent systematic review of ninety-six studies found that ovarian detorsion was not associated with thromboembolic events. Infection caused by irreversible damage to a necrotic adnexa during conservative surgery appears to be a very rare condition.[34] Postoperative fever, worsening abdominal pain, peritoneal signs, and haemodynamic instability should alert the patient to the development of peritonitis or sepsis.

If a benign mass is present, cystectomy (if possible) or cyst drainage may be performed after detorsion. If oedema prevents cystectomy and there is concern that dissection may compromise vascular perfusion, the procedure is postponed until a second session. Patients with ovarian preservation should be followed with ultrasound 6-12 weeks after detorsion so as to confirm ovarian function and rule out any underlying mass or malignancy.[5]

Theoretically, salpingo-oophorectomy may be indicated in cases of a non-viable ovary that is clearly necrotic/gelatinous,

with a complete loss of all normal anatomic structures, or in cases of high suspicion of malignancy of the ovary or fallopian tube based on serum tumour markers and previous ultrasonographic findings.[38] In our own clinical practice, we perform ovarian-sparing surgery by detorsion all torsed ovaries unless the torsed ovary is spontaneously amputated.

PREVENTION OF RECURRENCE

Individuals who have already had ovarian torsion seem to be more susceptible to recurrence. The risk of recurrent torsion in pediatric patients is estimated to be between 2% and 12%.[5,39] Pre-menarchal patients with normal ovaries may be at higher risk of recurrent torsion than those with an ovarian mass. Recurrent torsion may occur in the same ovary or the other ovary. In cases of previous unilateral oophorectomy or asynchronous bilateral torsion, oophoropexy can be performed by shortening the utero-ovarian ligament during laparoscopic surgery.[40] However, there is concern about its routine use because the long-term outcomes of oophoropexy are not yet known.[9,13,35,41] Moreover, oophoropexy is not recommended when a mass is present.

The effect of suppressing ovarian cysts with low-dose oestrogen-progestin oral contraceptives in post-menarchal patients in preventing recurrent torsions is uncertain.[3]

CONCLUSION

In children and adolescents, ovarian detorsion and preservation should be the preferred treatment procedure for suspected ovarian torsion, with prompt intervention via diagnostic laparoscopy. Risks of detorsion, such as thromboembolic events, sepsis, and malignancies, are extremely rare. The benefits of oophoropexy following a single case of ovarian torsion have not been fully established. The surgeon should not remove a torsed ovary if oophorectomy is avoidable (such as when a severely necrotic ovary is ruptured).

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The author has no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

The author declared that she participated in the design, execution, and analysis of the paper, and that she has approved the final version.

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MHA MEDIHEALTH ACADEMY

Surgery on Children

Case Report

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Mesenteric lymphatic malformation mimicking chylous ascites: a case report

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ABSTRACT

Mesenteric lymphatic malformations (MLM), previously referred to as mesenteric cysts, represent rare clinical entities. While these malformations are often asymptomatic, they can occasionally present with acute abdominal symptoms. The growth patterns as well as the fluid composition may vary. We present a case involving a 5-year-old patient who experienced progressive abdominal distention accompanied by an ascitic wave (initially misdiagnosed as ascites). A paracentesis was conducted, producing a cloudy fluid, which raised concerns for chylous ascites (CA), leading to additional diagnostic assessments. Surgical intervention became necessary when laboratories, fluid analyses, and imaging studies failed to provide a conclusive diagnosis. Ultimately, laparoscopy confirmed the presence of a mesenteric lymphatic malformation. Differentiating between MLM and CA poses significant challenges, highlighting the importance of considering MLM as a crucial differential diagnosis for CA. This paper aims to improve the accuracy of diagnoses to minimize the occurrence of unnecessary interventions. Importantly, the adoption of single-incision laparoscopy has proven to be a safe method, yielding favorable outcomes for this patient. However, continued research is essential to deepen our understanding and establish effective management protocols for these distinctive conditions.

Keywords: Abdominal pain, abdominal distention, mesenteric lymphatic malformations, chylous ascites

INTRODUCTION

Historically, mesenteric cysts and mesenteric lymphangiomas were traditionally described as different entities. Currently, both terms are included in a group called mesenteric lymphatic malformations (MLM).[1] Both entities refer to vascular anomalies rather than lymphatic system tumors.[1,3,4] MLM is rare, occurring in about 1 per 20.000 to 1 per 250.000 hospital admissions,[1,2] with around 5% found in the mesentery, making up 6% of childhood vascular anomalies.[2] These malformations are often asymptomatic,[1,2] but can present with non-specific symptoms or acute abdominal pain.[2,3] There are three described subtypes: microcystic, macrocystic, and mixed.[1] Macrocysts can enlarge, leading to the formation of giant cysts that may resemble ascites.[1] Some of them may contain chylous fluid, warranting differential diagnosis with chylous ascites (CA).[1,2]

CA is the accumulation of chylous-free fluid in the abdominal cavity, typically manifesting as painless abdominal distention but can also include abdominal pain and diarrhea.[5,6] Diagnosis often involves paracentesis showing milky fluid with high triglyceride content (>200 mg/dl), while imaging techniques have limited value.[5,6] Treatment options include a low-fat diet, medications to reduce blood flow, lymphangiography embolism, and surgery.[5,6]

Each entity exhibited varying morbidity and mortality,[2,5,6] highlighting the significance of accurate diagnosis and treatment. This report discusses a case of abdominal distention in a child and outlines the diagnostic process to distinguish between CA and MLM, presenting MLM as a differential diagnosis for CA and its clinical implications.

CASE

A previously healthy 5-year-old male presented to the emergency department with a 1-year history of abdominal

distension. The distension began after a minor abdominal trauma and gradually worsened over time, accompanied by decreased appetite. Upon physical examination, the only notable sign was the presence of an ascitic wave. An initial ultrasound (US) evaluation suggested the presence of an abdominal hematoma. Due to persistent abdominal distension, ascites were suspected, leading to a diagnostic paracentesis that yielded milky fluid. However, further analysis was limited by resources, prompting a referral to our institution. A repeat abdominal US revealed a large volume of fluid displacing adjacent structures without vascular compromise. Laboratory tests, including atrial natriuretic peptide, kidney and liver profiles, serum albumin, and protein levels, were normal, and neoplasm markers (CA 19-9, CA 125, alpha-fetoprotein) were negative.

Subsequently, new paracentesis resulted in the extraction of 2100 ml of milky fluid, with analysis indicating a pH of 8, a leukocyte count of 2993 (92% lymphocytes), 3.5 g/dl albumin, 4.8 g/dl total protein, 49 g/dl glucose, and 960 mg/dl triglycerides. Mycobacterial cultures and cytology were negative. Based on these findings, a diagnosis of CA was established, and the patient was placed on a low-lipid diet with medium-chain triglyceride supplementation. Although intestinal lymphangiectasia was initially suspected as a potential cause of the CA, this was ruled out through upper and lower gastrointestinal endoscopy and histopathological examinations. Lymphangiography was considered but ultimately not conducted due to technical constraints.

A magnetic resonance image (MRI) was performed, and upon initial review, the findings appeared comparable to those observed in the US. However, a more detailed analysis revealed a significant accumulation of non-free abdominal fluid. This fluid was not only a noteworthy detail but also influenced the positioning of the bowel loops, causing them to shift medially (**Figure 1**). This led to the consideration of mesenteric lymphatic malformation vs CA, prompting surgical exploration. During laparoscopic examination, a giant cystic malformation in the ileal mesentery was identified (**Figure 2**). Due to its adherence to the mesentery and compression of the intestinal vasculature, segmental intestinal resection with end-to-end anastomosis was performed.

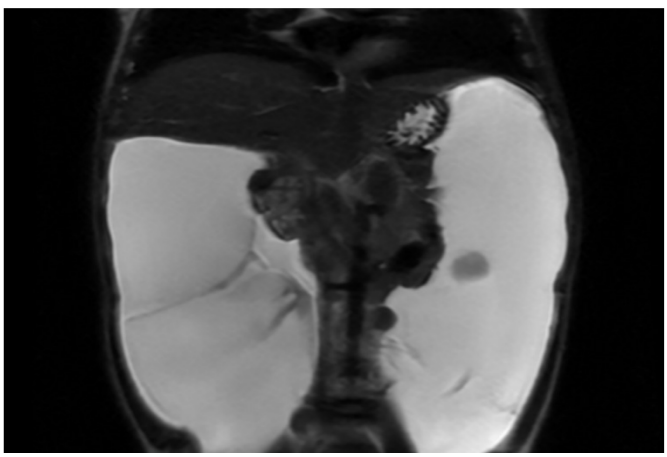

Figure 1. Magnetic resonance image of the patient. The coronal section illustrates the compressive effect of the bowel loops, indicated by the red arrow, which shows medial displacement. The black arrow highlights the trabeculated non-free fluid.

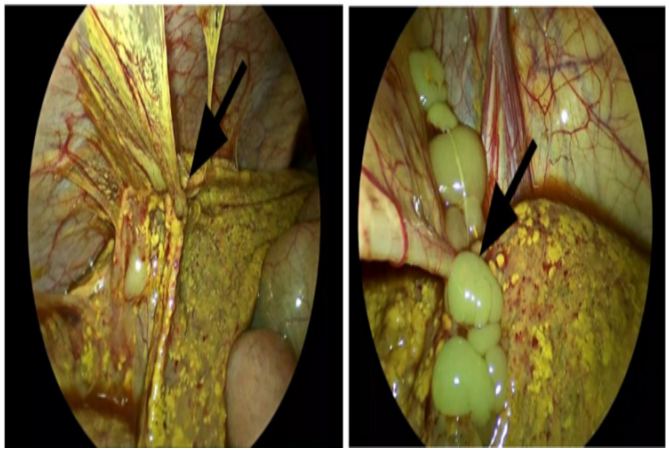

Figure 2. Laparoscopic findings. The left image displays the cyst, indicated by the arrow. The right image reveals the chylous content of the cyst being externalized into the abdominal cavity, as marked by the arrow.

Additionally, 600 ml of chylous fluid was drained from the cyst. The anatomopathological analysis confirmed the presence of a benign cystic lymphatic lesion with extensive xanthogranulomatous inflammation (**Figure 3**). Immunohistochemical features supported the diagnosis of a mesenteric lymphatic malformation. The postoperative period was uneventful, and the patient was discharged five days later.

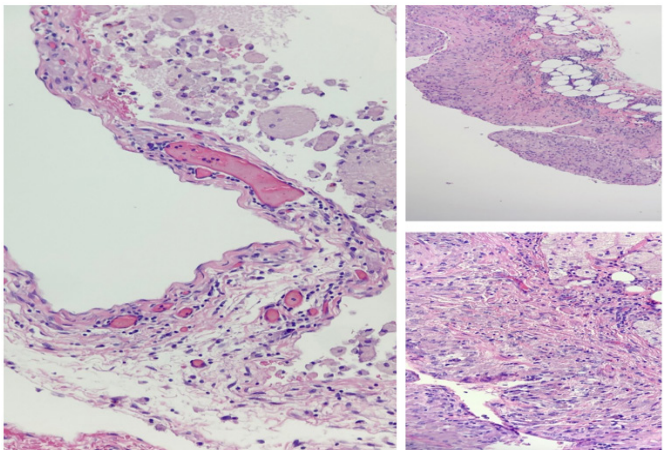

Figure 3. Histology of mesenteric malformations: The sections reveal fibro-adipose tissue with dilated cystic spaces partially covered by endothelial cells devoid of atypia. Additionally, foamy histiocytes are present, along with some lymphoid aggregates and nodules of reactive fibroblastic proliferation.

DISCUSSION

Lymphatic malformations are mainly found in the axilla and neck,[7,8] with the mesentery being a rare location (5% of cases).[1,3,9] The pathophysiology of this entity is still a controversial topic, and consensus has not been reached yet. Theories suggest either abnormal development of lymph vessels or obstruction of lymphatic flow.[1,7,8] Histologically, MLMs feature variable caliber vascular spaces with a protein meshwork, thin endothelial walls, and significant lymphocytic inflammation accompanied by a xanthogranulomatous reaction.[4] While often incidental, MLM can cause symptoms like abdominal pain, distention, nausea, vomiting, constipation, and diarrhea.[2,4] Complications such as hemorrhage, infection, cyst rupture, and volvulus have been noted. Diagnosis typically involves

US, with computed tomography (CT) and MRI offering better cyst characterization.[4,8] There are no established management algorithms; however, surgical excision is preferred for macrocysts, with sclerotherapy and sirolimus also accepted.[9-11]

In this case study, the patient was initially diagnosed with CA based on fluid triglyceride levels (>200mg/dl).[5,6] However, the paracentesis likely sampled fluid from the MLM rather than from free abdominal fluid. Various types of fluids, such as hematic, bilious, or serum, have been described[1,4,8] and chylous fluid in MLM has also been noted.[1,8] However, a large MLM resembling CA has not been documented. The patient's history of low-height abdominal trauma raises suspicion of CA, but CA is typically associated with high-energy trauma.[5]

Our case aligns with the typical epidemiology of MLM, where at least 60-90% are diagnosed by the patient's age,[1-3] with a reported male predominance.[3] Some studies, however, have noted an equal or female distribution.[1,7] The lymphatic malformation in our study was located in the ileal mesentery, a common site for this condition.[7] For symptomatic cases, CA typically presents with abdominal distention,[5,6] while MLM is often associated with abdominal pain.[7] In our patient, the progressive abdominal distention supports a CA diagnosis, although this symptom's frequency may be underestimated in MLM due to its growth alongside the patient,[7] making changes in abdominal perimeter less noticeable.

If well in our diagnostic workup US was the initial study, it was not until MRI was reviewed that the MLM diagnosis was contemplated. This imaging modality differentiates a cystic lesion from free abdominal fluid. Our experience is insufficient to recommend MRI as a diagnostic image in MLM, but it could be helpful to distinguish giant cystic lymphatic malformations from ascitic fluid. Some authors even report MRI as the gold standard for the lymphatic malformations diagnosis.[2] Moreover, it is known that MRI is associated with higher costs, and it is not widely available.

This report discusses a case where complete cyst excision with segmental intestinal resection was performed using single-incision laparoscopy, resulting in no complications during or after the procedure. While surgery remains the main treatment for MLM (especially macrocystic lesions),[7,9] some pediatric surgeons prefer open methods. Nevertheless, single-incision laparoscopy has shown to be a safe alternative, although more studies are needed to confirm its efficacy.[10,11]

CONCLUSION

CA and MLM are distinct yet often confounding conditions due to their overlapping symptoms. It is crucial to recognize each as a potential differential diagnosis for the other. Advanced diagnostic imaging plays a pivotal role in this differentiation; while US may have its limitations, MRI offers significant insights that can effectively distinguish between the two. Including MLM in the differential diagnosis of CA is not just prudent but essential—it can prevent unnecessary treatments and complications, paving the way for timely and effective management of MLM. Furthermore, the adoption of minimally invasive techniques, such as single-incision laparoscopy, represents a promising approach that can lead to favorable patient outcomes. However, further studies that provide higher levels of evidence should be conducted to develop comprehensive recommendations about the role of MRI as a crucial diagnostic tool as well as support the adoption of single-incision laparoscopy as a treatment approach for MLM.

ETHICAL DECLARATIONS

Informed Consent

The patient's parents signed the informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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