

Anesthetic management and perioperative outcomes in infants and young children undergoing diaphragmatic hernia or eventration repair: focus on two lung ventilation and propofol related hemodynamics

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Keypoints

Describes anesthetic management and early perioperative outcomes in infants with diaphragmatic hernia/eventration, with an exploratory focus on propofol induction.

Abstract

Introduction

To describe anesthetic management and early perioperative outcomes in infants and young children undergoing repair of congenital diaphragmatic hernia or diaphragmatic eventration at a tertiary center, with an exploratory analysis of patients who received propofol for induction.

Materials and Methods

We retrospectively reviewed 21 children who underwent repair under general anesthesia. Demographic characteristics, comorbidities, anesthetic technique, serial mean arterial pressure (MAP), vasoactive drug use, intraoperative complications, and early postoperative outcomes were collected. Propofol-exposed hernia and eventration subgroups were compared exploratorily.

Results

Fourteen children had hernia and seven had eventration. Conventional two-lung ventilation was used in 20/21 cases. In the propofol-exposed subgroup (n=14), median propofol dose was similar in hernia and eventration patients (6.0 [4.5-6.0] vs 5.0 [5.0-6.0] mg/kg; p=0.895). Absolute MAP decline from baseline was also similar. No bradycardia occurred; one hypotension episode was recorded.

Conclusion

In this single-center cohort, diaphragmatic repair was usually managed with intravenous induction, volatile maintenance, and two-lung ventilation. In selected propofol-exposed patients, no clear signal of major immediate propofol-related instability was observed. Larger multicenter studies are needed.

Keywords

congenital diaphragmatic hernia; diaphragmatic eventration; pediatric anesthesia; propofol; two-lung ventilation; single-lung ventilation

Introduction

Pediatric thoracic surgery is frequently encountered by anesthesiologists in tertiary care centers and is most commonly performed for conditions such as congenital malformations, neoplasms, and trauma (1, 2). When compared with adult anesthesia, pediatric thoracic anesthesia can be more difficult due to the wide variety of pathologies and the size limitations of available lung isolation devices (3).

Congenital diaphragmatic hernia (CDH) is a developmental discontinuity of the diaphragm that allows the

abdominal viscera to herniate into the chest (4). A substantial percentage of CDH cases are associated with additional abnormalities, including major structural anomalies in other organ systems such as, pulmonary hypertension, persistent patent ductus arteriosus, or foramen ovale, chromosomal abnormalities, and/or single gene disorders (5). Therefore all those things make thoracic surgery, especially CDH, much more challenging.

The prevalence of CDH is approximately 1 to 4 cases per 10,000 live births (6). In an analysis of data from 31 population-based European registries over a 29-year period and including over 12 million births, the overall prevalence of CDH was 2.3 per 10,000 live births and the prevalence of isolated CDH was 1.6 per 10,000 live births (7). Most studies have not observed a sex association, although at least one study reported a slightly higher prevalence in males (8).

Diaphragmatic eventration is pathophysiologically distinct from CDH and is characterized by replacement of diaphragmatic muscle with fibroelastic tissue, resulting in a thin and compliant diaphragm (9, 10).

Clinical presentation ranges from incidental findings to severe respiratory distress, and pediatric series suggest that diagnosis may occur from the neonatal period to late childhood (9, 11). From an anesthetic perspective, one unresolved practical issue is whether diaphragmatic surgery in very small children can be performed without routine single-lung ventilation (SLV). Although SLV is often recommended in pediatric thoracic surgery to improve surgical exposure and reduce mediastinal movement, reliable lung isolation in neonates and small infants may be technically difficult because of airway size, limited availability of appropriately sized bronchial blockers or double-lumen tubes, and the risk associated with repeated instrumentation (12). In many centers, particularly in resource-limited settings, advanced pediatric SLV equipment is not available at all. Under these circumstances, the feasibility and safety of performing diaphragmatic surgery without routine SLV are of particular clinical interest. Another unsettled question concerns

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induction technique. Propofol is widely used in pediatric anesthesia, but neonatal and infant data remain mixed. Preterm neonates may develop clinically significant hypotension after propofol induction (13), whereas selected full-term neonates and young infants have been reported to tolerate propofol induction without major short-term hemodynamic compromise (14). In diaphragmatic surgery, clinicians may therefore either avoid propofol altogether or individualize its use according to disease severity and baseline stability. Published evidence specific to diaphragmatic pathology is sparse and consists largely of case reports or small series, including isolated reports of propofol-based total intravenous anesthesia (TIVA) (15, 16).

The primary aim of this retrospective cohort study was to describe institutional anesthetic management and early perioperative outcomes in infants and young children undergoing repair of diaphragmatic hernia or eventration at a tertiary center. A key focus was to evaluate the clinical feasibility and safety of a standardized management protocol based on conventional two-lung ventilation (TLV) and volatile anesthesia, particularly in a setting where advanced lung isolation techniques were not routinely employed. A secondary exploratory aim was to examine the subgroup of patients who received propofol for induction and compare propofol-related hemodynamic profiles between the hernia and eventration groups. We hypothesized that perioperative respiratory stability could be maintained using a pragmatic TLV approach and that, among selected propofol-exposed patients, the propofol dose and early MAP decline would not differ substantially between diagnostic groups.

Materials and Methods

Study design and setting

This retrospective observational study was conducted at a tertiary care center with a specialized pediatric surgery department and an anesthesiology team experienced in pediatric care. The study protocol was approved by the institutional ethics committee, and the requirement for

written informed consent was waived due to the retrospective design and anonymization of data.

Patient selection

Hospital electronic and paper records were searched to identify all infants and young children who underwent surgical repair of diaphragmatic hernia or diaphragmatic eventration over a 8-year period. Inclusion criteria were: diagnosis of diaphragmatic hernia or diaphragmatic eventration confirmed by imaging and/or surgical findings, and elective or urgent surgical repair under general anesthesia. Patients were excluded if they underwent isolated abdominal procedures without diaphragmatic repair or if essential anesthetic records were missing. A total of 21 patients met the inclusion criteria and formed the study cohort.

Data collection

Data were extracted from anesthetic charts, perioperative notes, and intensive care records using a standardized data collection form. The following variables were recorded: demographics and preoperative status (age, weight, sex, ASA class, diagnosis, comorbidities, and preoperative intubation/respiratory support); surgical and anesthetic management (surgical approach, duration, endotracheal tube type and size, use of SLV, induction agents and weight-based doses, maintenance anesthetic, supplemental intravenous agents, vasoactive and inotropic drugs, and diuretics); intraoperative physiologic variables (baseline and serial SpO₂, EtCO₂, mean arterial pressure [MAP], and heart rate, from which minimum SpO₂, maximum EtCO₂, and minimum MAP were extracted); intraoperative complications and interventions (hypotension, bradycardia, bleeding, and their treatment); and postoperative outcomes (extubation status, postoperative mechanical ventilation, ICU admission, early complications, and in-hospital mortality). For the exploratory propofol-focused analysis, the weight-based induction dose of propofol (mg/kg) and serial MAP values at baseline and at 15, 30, 60, and 90 minutes after induction, as well as at the end of surgery, were specifically recorded to assess early hemodynamic patterns.

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Outcome definitions

The perioperative outcomes of interest were defined in accordance with the pragmatic clinical focus of the study, which was to describe the institutional use of conventional two-lung ventilation during diaphragmatic repair and to explore the short-term hemodynamic profile of propofol induction in selected patients. Respiratory profile during surgery was assessed using serial oxygen saturation and end-tidal carbon dioxide measurements, with minimum intraoperative SpO₂ and maximum intraoperative EtCO₂ used as summary indicators. Hemodynamic profile was assessed using serial mean arterial pressure (MAP) and heart rate measurements obtained during the procedure. Hypotension was defined pragmatically as an intraoperative decrease in blood pressure considered clinically significant by the attending anesthesiologist and requiring treatment, such as fluid administration and/or vasoactive support. Bradycardia was defined as a decrease in heart rate prompting pharmacologic intervention or explicit chart documentation. For the exploratory propofol-focused analysis, baseline MAP was defined as the value recorded before induction (MAP₀), and subsequent MAP values at 15, 30, 60, and 90 minutes after induction, as well as at the end of surgery, were used to characterize the early hemodynamic course. Minimum intraoperative MAP was defined as the lowest recorded MAP among the intraoperative time points.

Statistical analysis

Continuous variables were summarized as mean \pm standard deviation (SD) or median and interquartile range (IQR), according to distribution and clinical interpretability. Categorical variables were expressed as counts and percentages. For the primary analysis, descriptive statistics were used to characterize institutional anesthetic management, with particular focus on the pragmatic use of two-lung ventilation (TLV), and to summarize early perioperative outcomes. Exploratory between-group comparisons in the overall cohort were performed using the Mann–Whitney U test for continuous variables and Fisher’s exact test for categorical variables. A secondary

exploratory subgroup analysis focused on patients who received propofol for induction. Within this subgroup, patients with diaphragmatic hernia were compared with those with eventration using the Mann–Whitney U test for continuous variables and Fisher’s exact test for categorical variables. Given the small sample size and the exploratory nature of the study, all p-values were interpreted descriptively, no adjustment was made for multiple comparisons, and no multivariable modeling was performed.

Results

Twenty-one infants and young children were included in the analysis, of whom 14 (66.7%) had diaphragmatic hernia and 7 (33.3%) had diaphragmatic eventration. Baseline characteristics are summarized in Table 1. The cohort was very young overall, with a median age of 2.0 months (IQR 0.0–13.0) and median weight of 5.2 kg (IQR 3.2–10.5). Patients with hernia tended to be younger and lighter than those with eventration: median age 0.5 months (IQR 0.0–10.5) vs. 13.0 months (IQR 7.0–36.5; $p=0.065$) and median weight 3.7 kg (IQR 2.9–6.8) vs. 10.5 kg (IQR 6.8–16.6; $p=0.030$), respectively. Overall, 9 patients (42.9%) were female, with a similar sex distribution between the hernia and eventration groups (50.0% vs. 28.6% female; $p=0.642$). The majority of the cohort had substantial systemic disease burden. Across all patients, ASA physical status was II in 10 (47.6%), III in 3 (14.3%), and IV in 8 (38.1%). However, disease severity differed markedly between diagnostic groups: among hernia patients, 57.1% were ASA IV and only 21.4% were ASA II, whereas all eventration patients were classified as ASA II. Comorbidities were frequent, particularly in the hernia group. Any comorbidity was present in 13 patients (57.1%) overall, but in 12 of 14 children with hernia (85.7%) compared with only 1 of 7 with eventration (14.3%; $p=0.003$). Cardiac anomalies were the predominant comorbidity, affecting 12 patients (57.1%) overall; all of these patients were in the hernia group (12/14, 85.7%), whereas none were observed in the

eventration group (0/7, 0.0%; $p<0.001$). Down syndrome was documented in one child (4.8%), who belonged to the eventration group. Two patients (9.5%) had two or more comorbidities. Preoperative respiratory support further highlighted the difference in baseline severity. Overall, 7 children (33.3%) required mechanical ventilation before surgery; all of these were in the hernia group (50.0% of hernia patients vs. 0% of eventration patients; $p=0.047$). Taken together, these findings indicate that the diaphragmatic hernia subgroup comprised smaller, sicker infants with a higher prevalence of complex cardiac disease and preoperative ventilatory dependence compared with the eventration subgroup.

Variable	All patients (n=21)	Hernia (n=14)	Eventration (n=7)	p-value
Age, months, median [IQR]	2.0 [0.0–13.0]	0.5 [0.0–10.5]	13.0 [7.0–36.5]	0.065
Weight, kg, median [IQR]	5.2 [3.2–10.5]	3.7 [2.9–6.8]	10.5 [6.8–16.6]	0.030
Female sex, n (%)	9 (42.9%)	7 (50.0%)	2 (28.6%)	0.642
ASA II, n (%)	10 (47.6%)	3 (21.4%)	7 (100.0%)	—
ASA III, n (%)	3 (14.3%)	3 (21.4%)	0 (0.0%)	—
ASA IV, n (%)	8 (38.1%)	8 (57.1%)	0 (0.0%)	—
Any comorbidity, n (%)	13 (57.1%)	12 (85.7%)	1 (14.3%)	0.003
Cardiac anomaly, n (%)	12 (57.1%)	12 (85.7%)	0 (0.0%)	<0.001
Down syndrome, n (%)	1 (4.8%)	0 (0.0%)	1 (14.3%)	0.333
≥2 comorbidities, n (%)	2 (9.5%)	2 (14.3%)	0 (0.0%)	0.533
Preoperative mechanical ventilation, n (%)	7 (33.3%)	7 (50.0%)	0 (0.0%)	0.047

Table 1. Baseline characteristics of infants and young children undergoing surgery for diaphragmatic hernia or eventration.

Anesthetic and intraoperative management characteristics are summarized in Table 2. All children underwent intravenous induction, most commonly with propofol and an opioid, followed by maintenance with a volatile anesthetic agent. Seven procedures (33.3%) were performed via open laparotomy and 14 (66.7%) via laparoscopy. The mean duration of surgery for the entire cohort was 140.5 ± 61.0 minutes, and did not differ significantly

between laparotomy and laparoscopy (120.0 ± 41.8 vs. 150.7 ± 67.6 minutes; $p=0.312$). Laparoscopic procedures were associated with higher induction doses of propofol and remifentanyl, as reflected by higher median weight-based doses in this group. Rocuronium was used in the majority of cases overall. Intraoperative oxygenation and ventilation were generally preserved. The mean minimum intraoperative SpO₂ was $94.5 \pm 5.2\%$ overall, with a trend toward lower values in the laparotomy group ($91.0 \pm 6.6\%$ vs. $96.2 \pm 3.4\%$; $p=0.051$). The mean maximum ETCO₂ was 39.9 ± 7.7 mmHg, with no relevant difference between open and laparoscopic procedures ($p=0.477$).

Variable	All patients (n=21)	Laparotomy (n=7)	Laparoscopy (n=14)
Duration of surgery, min, mean \pm SD	140.5 \pm 61.0	120.0 \pm 41.8	150.7 \pm 67.6
Induction propofol dose, mg/kg, median [IQR]*	5.00 [0.00–6.00]	0.00 [0.00–2.50]	5.00 [4.12–6.00]
Induction remifentanyl dose, mcg/kg, median [IQR]*	0.50 [0.00–1.00]	0.00 [0.00–0.25]	0.50 [0.50–1.00]
Rocuronium used, n (%)	18 (85.7%)	6 (85.7%)	12 (85.7%)
Single-lung ventilation used, n (%)	1 (4.8%)	0 (0.0%)	1 (7.1%)
Cuffed endotracheal tube, n (%)	5 (23.8%)	1 (14.3%)	4 (28.6%)
Minimum intraoperative SpO ₂ , %, mean \pm SD	94.5 \pm 5.2	91.0 \pm 6.6	96.2 \pm 3.4
Maximum intraoperative EtCO ₂ , mmHg, mean \pm SD	39.9 \pm 7.7	40.9 \pm 9.7	39.4 \pm 6.7
Minimum intraoperative MAP, mmHg, mean \pm SD	42.9 \pm 10.5	36.0 \pm 8.0	46.3 \pm 10.1
Any hypotension episode, n (%)	6 (28.6%)	5 (71.4%)	1 (7.1%)
Any bradycardia episode, n (%)	5 (23.8%)	3 (42.9%)	2 (14.3%)
Use of vasoactive/inotropic infusion, n (%)	8 (38.1%)	4 (57.1%)	4 (28.6%)

Table 2. Anesthetic management and intraoperative physiologic variables according to surgical approach.

Advanced airway and ventilatory techniques were rarely employed. A cuffed endotracheal tube was used in 23.8% of children, with no significant difference between approaches. Intentional single-lung ventilation was used in

only one case (4.8%), which occurred in the laparoscopic group; all remaining surgeries were performed with conventional two-lung ventilation, relying on careful surgical exposure and ventilatory adjustments. Hemodynamic instability, predominantly hypotension, was more frequent in the open surgery group. The mean minimum intraoperative MAP was 42.9 ± 10.5 mmHg overall, but children undergoing laparotomy had a lower minimum MAP than those undergoing laparoscopy (36.0 ± 8.0 vs. 46.3 ± 10.1 mmHg; $p=0.040$). Clinically defined hypotension occurred in 6 patients (28.6%) overall, but in 71.4% of laparotomy cases compared with 7.1% of laparoscopic cases ($p=0.006$). Bradycardia episodes were documented in 5 children (23.8%), more often after laparotomy than laparoscopy, although this difference did not reach statistical significance. Vasoactive or inotropic drugs were used in approximately one-third of the cohort, with a numerically higher proportion in the laparotomy group.

A focused exploratory analysis of propofol-exposed patients is shown in Table 3. Fourteen children received propofol for induction: 7 with hernia and 7 with eventration. All propofol-exposed patients were preoperatively extubated. Median propofol dose did not differ meaningfully between propofol-exposed hernia and eventration patients ($6.0 [4.5–6.0]$ vs $5.0 [5.0–6.0]$ mg/kg; $p=0.895$). Baseline MAP and minimum intraoperative MAP were numerically lower in the hernia subgroup, but neither absolute MAP decline nor percentage MAP decline from baseline differed significantly between groups.

Among propofol-exposed patients, no bradycardia was documented in either subgroup. Only one hypotension episode occurred in the propofol-exposed subgroup, and this was observed in a hernia patient. Importantly, propofol exposure was not randomly distributed across the entire cohort: the seven patients who did not receive propofol were all preoperatively intubated ASA IV hernia patients.

In those non-propofol cases, induction relied mainly on rocuronium with fentanyl, with one case also receiving

midazolam, suggesting that induction strategy was individualized according to baseline severity.

Variable	Propofol-exposed hernia (n=7)	Propofol-exposed eventration (n=7)	p-value
Age, months, median [IQR]	12.0 [4.0–30.0]	13.0 [7.0–36.5]	0.700
Weight, kg, median [IQR]	7.0 [5.7–9.5]	10.5 [6.8–16.6]	0.306
ASA II / III / IV, n	3 / 3 / 1	7 / 0 / 0	—
Laparotomy / laparoscopy, n	2 / 5	0 / 7	—
Propofol dose, mg/kg, median [IQR]	6.0 [4.5–6.0]	5.0 [5.0–6.0]	0.895
MAP0 (baseline), mmHg, median [IQR]	60.0 [43.5–64.0]	67.0 [55.5–67.5]	0.140
MAP15, mmHg, median [IQR]	52.0 [45.5–54.5]	58.0 [51.0–60.5]	0.337
MAP30, mmHg, median [IQR]	49.0 [40.5–54.0]	55.0 [51.5–58.5]	0.054
MAP60, mmHg, median [IQR]	47.0 [43.0–51.5]	52.0 [49.5–57.5]	0.224
End-of-surgery MAP, mmHg, median [IQR]	58.0 [52.5–63.5]	67.0 [58.0–68.0]	0.248
Minimum intraoperative MAP, mmHg, median [IQR]	42.0 [40.0–51.0]	52.0 [47.0–56.0]	0.139
Absolute MAP decline from baseline, mmHg, median [IQR]	–8.0 [–15.0 to –3.5]	–10.0 [–14.0 to –6.5]	0.798
Percentage MAP decline from baseline, %, median [IQR]	12.7 [8.0–22.7]	14.9 [13.8–20.7]	0.710
Any hypotension episode, n (%)	1 (14.3%)	0 (0.0%)	1.000
Any bradycardia episode, n (%)	0 (0.0%)	0 (0.0%)	1.000

Table 3. Exploratory analysis restricted to propofol-exposed patients, according to diagnosis.

Postoperative respiratory support and early outcomes are shown in Table 4. Thirteen children (61.9%) were extubated in the operating room at the end of the procedure. Extubation in the operating room was more frequent among patients with eventration than those with hernia (85.7% vs. 50.0%; $p=0.174$), whereas postoperative mechanical ventilation was required in 8 patients (38.1%) overall and was more common in the hernia group (50.0% vs. 14.3%; $p=0.174$). Although these differences did not reach statistical significance, they are consistent with the greater baseline severity observed in the hernia subgroup. Red blood cell transfusion was administered to

one patient (4.8%), who belonged to the hernia group. Three children (14.3%) died during the hospital stay; all of these deaths occurred in the diaphragmatic hernia group (21.4% vs. 0% in the eventration group; $p=0.521$). Given the small sample size, these findings should be interpreted with caution, but they suggest that mortality in this cohort was concentrated among the youngest and sickest infants with complex diaphragmatic hernia and associated comorbidities.

Variable	All patients (n=21)	Hernia (n=14)	Eventration (n=7)	p-value
Extubated in operating room, n (%)	13 (61.9%)	7 (50.0%)	6 (85.7%)	0.174
Postoperative mechanical ventilation, n (%)	8 (38.1%)	7 (50.0%)	1 (14.3%)	0.174
Red blood cell transfusion, n (%)	1 (4.8%)	1 (7.1%)	0 (0.0%)	1.000
In-hospital mortality, n (%)	3 (14.3%)	3 (21.4%)	0 (0.0%)	0.521

Table 4. Postoperative respiratory course, transfusion, and mortality according to diagnosis.

Discussion

This retrospective cohort study describes anesthetic management and early perioperative outcomes in 21 infants and young children undergoing surgical repair of congenital diaphragmatic hernia or diaphragmatic eventration. The cohort comprised predominantly high-risk patients: most were neonates or young infants, more than half had cardiac anomalies, and one-third required mechanical ventilatory support before surgery. Despite this disease burden, all but one procedure were completed successfully under conventional two-lung ventilation (TLV) with intravenous induction and volatile anesthetic maintenance, and perioperative oxygenation and hemodynamic parameters were generally maintained within acceptable limits. A focused exploratory analysis further revealed that, among the selected subgroup who received propofol for induction, no bradycardia occurred and only one hypotension episode was recorded, with comparable propofol dose distributions and MAP decline from baseline between the hernia and eventration groups.

Single-lung ventilation is widely recommended in pediatric thoracic surgery to optimize surgical exposure, reduce mediastinal movement, and protect the dependent lung (12). However, reliable lung isolation in neonates and small infants is technically demanding due to limited airway dimensions and the scarcity of appropriately sized bronchial blockers or double-lumen tubes (12). In resource-limited settings, advanced SLV equipment may not be available at all. In our cohort, SLV was employed in only one case; all remaining procedures relied on TLV combined with low-pressure pneumoperitoneum, careful ventilatory adjustment, and close intraoperative communication between the anesthetic and surgical teams. The mean minimum intraoperative SpO₂ across the cohort was 94.5 ± 5.2% and the mean maximum EtCO₂ was 39.9 ± 7.7 mmHg, indicating that adequate gas exchange was maintained in the great majority of cases. These findings extend those of Liu et al., who reported a 45-neonate retrospective series of thoracoscopic CDH and EA/TEF repairs performed without lung isolation, in which intraoperative hypoxemia (SpO₂ <90%) occurred in 31.1% of patients but was predominantly transient and responded promptly to ventilatory intervention (17). Similarly, Shang et al. recently documented successful thoracoscopic CDH repair under TLV with CO₂ insufflation in 48 pediatric patients, confirming the feasibility of this approach in experienced hands (18). Taken together, these reports and our own data suggest that SLV is not an absolute prerequisite for diaphragmatic surgery in infants, provided that ventilatory strategy is individualized, surgical-anesthetic communication is robust, and arterial oxygenation is closely monitored.

The intraoperative differences observed between laparoscopic and open surgical groups warrant careful contextual interpretation. Children undergoing laparotomy had a significantly lower minimum intraoperative MAP (36.0 ± 8.0 vs 46.3 ± 10.1 mmHg; p=0.040) and a markedly higher rate of clinically defined hypotension (71.4% vs 7.1%; p=0.006). However, these differences almost certainly reflect confounding by indication rather than a true *Ata et al. Anesthetic management in diaphragmatic hernia*

effect of surgical approach. The laparotomy group was systematically composed of sicker patients — with higher proportions of ASA IV classification, cardiac comorbidities, and preoperative ventilator dependence — compared with the laparoscopy group. As acknowledged in the limitations, confounding by severity is unavoidable in this retrospective, non-randomized design, and subgroup comparisons between surgical approaches should be considered hypothesis-generating only. Consistent with this interpretation, the intraoperative anesthetic challenges of CDH repair — including difficulty maintaining PaCO₂ control, hemodynamic lability in patients with pulmonary hypertension, and the physiological impact of open versus thoracoscopic approaches — are well recognized in the literature (19).

The propofol findings merit specific discussion in the context of existing evidence. Propofol is known to produce dose-dependent cardiovascular depression, primarily through reduction of sympathetic vascular tone and decreased systemic vascular resistance; standard induction doses of 2–2.5 mg/kg have been associated with reductions in systolic blood pressure of 25–40% in pediatric patients (20). This hemodynamic vulnerability is potentially heightened in neonates and preterm infants, in whom propofol-induced hypotension may be profound and prolonged (13). At the same time, selected term neonates and young infants undergoing major surgery have been shown to tolerate propofol induction with hemodynamic profiles comparable to sevoflurane inhalation induction, with no increase in adverse events (14). It is important to note that the evidence for severe propofol-induced hemodynamic compromise is most robust in preterm and critically ill neonates, whereas our propofol-exposed subgroup consisted predominantly of older infants — median age 12.0 months in the hernia group and 13.0 months in the eventration group — a population likely more tolerant of propofol induction. Within our propofol-exposed subgroup (n=14), the median propofol dose did not differ between hernia and eventration patients (6.0 [4.5–6.0] vs 5.0 [5.0–6.0] mg/kg; p=0.895), and the

absolute MAP decline from baseline was comparable between groups (-8.0 [-15.0 to -3.5] vs -10.0 [-14.0 to -6.5] mmHg; $p=0.798$). Only one hypotension episode was recorded in the propofol-exposed group, in a hernia patient. Importantly, all seven patients who did not receive propofol were preoperatively intubated ASA IV patients with diaphragmatic hernia, indicating that induction strategy in our cohort appeared to be individualized according to baseline clinical severity.

These observations suggest that a categorical rule of routine propofol avoidance in all patients with diaphragmatic pathology may be overly simplistic. Our data indicate that in selected, non-intubated patients with preserved baseline hemodynamic stability, propofol induction did not generate an obvious signal of major immediate cardiovascular compromise. Nevertheless, this conclusion must be heavily qualified: the sample size is small, the analysis is retrospective and exploratory, confounding by indication is substantial, and charted MAP values rather than prospectively standardized hemodynamic monitoring were used. Our data do not support a pro-propofol recommendation; rather, they support the principle of individualized induction agent selection based on each patient's preoperative status, comorbidity profile, and hemodynamic reserve. Future multicenter prospective studies should stratify patients by preoperative intubation status, pulmonary hypertension severity, cardiac comorbidity, and gestational maturity in order to compare induction strategies with adequate power and appropriate confounder control.

Our findings also have implications for the broader direction of pediatric thoracic anesthesia. The field is moving toward increasingly individualized perioperative strategies, in which anesthetic and ventilatory management are tailored according to disease severity, pulmonary hypoplasia, pulmonary hypertension burden, cardiac reserve, and institutional resources. In this context, more structured perioperative assessment and larger multicenter datasets may help refine patient selection and clinical decision-making in the coming years. Although limited in *Ata et al. Anesthetic management in diaphragmatic hernia*

scale, the present study provides a real-world data point from a resource-limited tertiary center and suggests that acceptable short-term outcomes may be achieved in this high-risk population with a pragmatic anesthetic approach, provided that careful monitoring, experienced multidisciplinary teamwork, and individualized patient management are in place.

This study has several important limitations that must be acknowledged. First, the retrospective single-center design limits generalizability and introduces selection bias, as patients with missing records were excluded. Second, the total sample size of 21 patients is small, rendering all subgroup analyses substantially underpowered; confidence intervals around key estimates are wide, and all comparisons should be considered exploratory and hypothesis-generating rather than confirmatory. Third, the diagnostic and surgical subgroups were clinically imbalanced — the hernia and laparotomy groups comprised disproportionately sicker patients — making confounding by indication unavoidable and precluding valid causal inference. Fourth, no multivariable regression analysis was feasible given the sample size. Fifth, the propofol-focused analysis relied on available charted MAP values rather than prospectively standardized hemodynamic monitoring windows, and the timing of MAP measurements was not uniform across cases. Finally, long-term respiratory, neurodevelopmental, and quality-of-life outcomes were not assessed, limiting conclusions to the immediate perioperative period only.

Conclusion

In this retrospective cohort study, infants and young children undergoing diaphragmatic hernia or eventration repair were most commonly managed with intravenous induction, volatile maintenance, and conventional two-lung ventilation.

In the exploratory subgroup of patients who received propofol for induction, propofol-exposed hernia and eventration patients had similar dose distributions and similar MAP decline from baseline, with no bradycardia

and only one hypotension episode recorded. These findings suggest that categorical routine avoidance of propofol in all such patients may be overly simplistic. Nevertheless, the small sample size and strong confounding by severity preclude practice-changing conclusions, and larger multicenter studies are needed.

Disclosure / acknowledgements

Ethics approval and consent to participate

The study commenced after receiving local ethics committee approval (25.06.2019/08).

Consent for publication

Not applicable.

Conflict of interest statement

The author declares no conflict of interest related to this study.

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Availability of data and material

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to ethical restrictions and patient confidentiality.

Author contribution

All authors wrote the main manuscript text, A.R.A prepared tables 1-4. All authors reviewed the manuscript.

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