JCTEI
JOURNAL OF CLINICAL TRIALS AND EXPERIMENTAL INVESTIGATIONS
Year: 2023 Volume: 2 Issue: 3

ORIGINAL ARTICLE

10.5281/zenodo.8289545

Laryngeal mask anesthesia during surgical treatment of pediatric patients with hydrocephalus

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Received: 1 July 2023
Revised: 27 July 2023
Accepted: 30 July 2023
Published: 29 August 2023

Keywords
- Anesthesia
- Hydrocephalus
- Laryngeal mask anesthesia
- Ventriculoperitoneal shunt

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Abstract

Objective: In hydrocephalic patients, peri-operative processes that reduce the risk of complications due to difficult intubation are essential. With this study, perioperative process evaluation of laryngeal mask and endotracheal intubation as an airway method in pediatric hydrocephalus patients is appropriately targeted for hydrocephalus patient management.

Materials and methods: This retrospective study included patients diagnosed with hydrocephalus who underwent surgical treatment using a ventriculoperitoneal shunt. The study sample was divided two groups [endotracheal intubation (EI) and laryngeal mask (LMA)] based on the method of anesthesia administration.

Results: The study included 81 patients with a mean age of 11.0±30.604 months. No significant differences in age, number of surgeries, body mass index, head circumference, incidence of laryngeal spasms, surgical duration, and volume of air leakage were observed between the groups. However, the duration of anesthesia (p=0.000), hospital and intensive care stay (p=0.007 and p=0.049, respectively), and airway establishment (p=0.049) were significantly shorter in the LMA group. Moreover, the number of attempts required for airway establishment was also low in this group (p=0.033).

Conclusions: LMA, when used appropriately, can minimize the need for post-operative intensive care, shorten the length of hospital stay, enable early nutrition, and reduce the risk of hypothermia in pediatric patients with high risk of comorbidities. Moreover, this procedure can also potentially be life-saving during the peri-operative period, particularly in high-risk patients that are difficult to intubate and exhibit higher rates of comorbidities.

Cite as: Aktiz Bicak E, Arpa A. Laryngeal mask anesthesia during surgical treatment of pediatric patients with hydrocephalus. J Clin Trials Exp Investig. 2023;2(3):153-158.

Abbreviation list

ASA: American Society of Anesthesiology score
BMI: body mass index
CSF: cerebrospinal fluid
EI: endotracheal intubation
LMA: laryngeal mask anesthesia
V-P: ventriculoperitoneal

Introduction

Hydrocephalus, caused by the accumulation of cerebrospinal fluid (CSF), can lead to an increase in head circumference (i.e., macrocephaly) during early childhood when the fontanelles are still open (1). During anesthesia, maintenance of clear airways and continuity of breathing is essential and requires timely identification of potential obstacles, implementation of necessary precautionary measures, and appropriate selection and implementation of techniques (2). Pediatric respiratory systems are anatomically and functionally different from those of adults, characterized by higher respiratory rates, lower lung compliance, decreased expiratory reserve volume due to reduced functional residual capacity, and increased chest wall compliance. Moreover, these patients also exhibit shorter trachea and neck, bigger adenoids and tonsils, anterior and cephalic positioning of the larynx, and larger omega-shaped epiglottis of the tongue which make them more vulnerable when compared to adults (3). Macrocephaly can alter the normal skull anatomy, causing enlargement of the occiput and widening of the forehead which, in turn, result in excessive flexion of the neck, limited laryngoscopic view, and airway obstruction (1,4).

Laryngeal masks can help establish effective airways when placed in the hypopharynx of patients with good tolerance, even under very light sedation. It has several advantages including ease of insertion; decreased invasiveness; lower risk of trauma to the teeth and larynx; convenience during difficult intubation; and decreased incidence of laryngospasms and bronchospasms. Furthermore, it also allows the anesthetist to work with his hands freely. The main disadvantage of this procedure is its inability to close the airway during regurgitation of gastric contents (5).

Therefore, the current study compared the efficacy of using laryngeal masks and endotracheal intubation for the establishment of airways during the peri-operative period in pediatric patients with hydrocephalus, with the aim of identifying the most suitable method of management in these patients.

Materials and methods

This retrospective study included 81 patients who underwent ventriculoperitoneal (V-P) shunting for hydrocephalus between January 2018 and December 2020. The study sample was randomly divided into two groups [endotracheal intubation (EI) and laryngeal mask (LMA)] based on the method of administration of anesthesia. Patient age, gender, body mass index (BMI), head circumference, etiology of hydrocephalus, presence of additional anomalies, and type of surgery were recorded. Pre-operative evaluation included assessment of the patient's American Society of Anesthesiology (ASA) score and their pre-, peri-, and early post-operative saturation levels, arterial blood pressure, the number of attempts required and the associated time, leakage volume, surgical time, presence of laryngeal spasms, and duration of anesthesia. Furthermore, post-operative hospital stays and the need for intensive care were also assessed.

General anesthesia was administered in all patients by the same team, and the surgical interventions were carried out by one neurosurgeon. Patients requiring different surgeries in the same session and those requiring additional treatment for comorbidities were excluded from the study. Patients with cleft palate lip, oropharyngeal deformity, esophageal motility disorders etc. pathologies that would affect the anesthesia technique were excluded from the study. With this, patients with additional pathology and therefore a history of prolonged hospitalization and/or intubation were excluded from the study.

Electrocardiography, pulse oximetry, and non-invasive blood pressure monitoring was carried out during the surgical procedure. Preparations such as video-laryngoscopes were made in anticipation of difficult airways, and induction was carried out using 0.1mg/kg midazolam (Dormicum® 5mg/5ml, Roche, Turkey), 1mcg/kg fentanyl (Talinat, Vem, Istanbul, Turkey), and 2–3mg/kg propofol (Propofol 1% Fresenius®; Fresenius Kabi Medicine, Istanbul, Turkey). In the LMA group, a laryngeal mask that was appropriately sized for the patient's weight was placed and mechanical ventilation (Dräger Primus; Dräger AG, Lübeck, Germany) was started. In the EI group, 0.6mg/kg rocuronium (Esmeron®, Merck Sharpoo Dohme (MSD) Pharmaceuticals Ltd., Germany) was first administered for muscle relaxation, followed by orotracheal intubation and mechanical ventilation using an appropriately sized endotracheal tube (Dräger Primus; Dräger AG, Lübeck, Germany). Anesthesia was maintained using 2-3% sevoflurane in

both groups. Surgery was carried out in the supine position and all intra-operative vital signs were recorded. Intubated patients were extubated after surgery, and LMA was withdrawn upon establishment of sufficient spontaneous respiration. Any post-operative complications observed were recorded.

This study was approved by the Ethics Committee of the University of Health Sciences, Diyarbakir Gazi Yasargil Education and Research Hospital (approval date and number: 13.03.2022/440), and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent was collected from all patients prior to commencement of the study.

Statistical analysis

All statistical analyses were performed using the statistical program, SPSS (Version 24.0; SPSS Inc., Chicago, IL, USA). All clinical parameters were analyzed, with continuous variables being expressed as mean±SD and categorical ones as percentages. The Chi-square and One-Way ANOVA tests were used to analyze categorical and continuous variables, respectively, and a p-value<0.05 was considered statistically significant.

Results

The study sample included 81 patients, of which 51.9% were girls and 48.1% were boys. The mean age [11.0 ±30.604 months; range: 0-247 months]; number of surgeries [1.92 ±1.069; range: 1-5]; BMI [15.85±3.175; range: 9.54-21.72]; and head circumference [42.012±5.370; range: 32-57 cm] of the study sample have been shown in Table 1. Regarding the etiology of hydrocephalus, 12.3% of the patients exhibited encephalocele, 14.8% had a history of intraventricular hemorrhage, 54.3% presented with spina bifida, and 18.5% were congenital.

Additional anomalies were present in 69.1% of hydrocephalus patients, and these included Fallot's tetralogy, renal anomalies (e.g., polycystic kidney, horseshoe kidney, renal agenesis-atresia, pelvicalyceal system pathologies, neurogenic bladder causing renal dysfunction etc.), cardiac anomalies (e.g., ASD, VSD etc.), and lung pathologies (e.g., low lung capacity secondary to advanced scoliosis, laryngomalacia, diaphragmatic hernia etc.). No midline closure defects were observed.

In the current study the mean ASA score was 2.37 (range: 1 to 4); total time including anesthesia was 64.38±15.35 minutes (range: 30 to 120 minutes); surgical time was 32.28±5.42 minutes (range: 20 to 50 minutes); pre-operative saturation level was 96.69±1.38 (range: 90 to 98); peri-operative saturation

Table 1. Patient demographics by type of anesthesia (LMA and EI)

	EI* (n=45)	LMA** (n=36)	Total (n=81)	p-value
Age (month)	9.06±19.1	13.4±40.8	11.0±30.6	0.528
Number of surgeries	2.11±1.07	1.69±1.03	1.92±1.06	0.081
BMI	15.95±3.6	15.73±2.5	15.85±3.17	0.755
Head circumference (cm)	41.8±6.2	42.1±4.1	42.01±5.37	0.787
Spasm (%)	11.1%	5.6%	8.6%	0.319
ASA***	2.6±0.60	2.0±0.41	2.3±0.62	0.288
Anesthesia time (minute)	70.8±15.	56.2±10.1	64.3±15.3	0.000
Surgery time (minute)	33.0±5.1	31.3±5.6	32.2±5.4	0.186
Length of hospitalization (hour)	49.6±19.6	38.6±15.4	44.7±18.4	0.007
Length of intensive care (hour)	11.4±15.7	5.2±10.3	8.8±13.9	0.049
Leakage (ml)	2.11±2.7	3.08±2.9	2.54±2.8	0.129
Airway placement time (second)	104.5±56.1	74.0±80.4	91.1±69.1	0.049
Number of attempts	1.6±0.8	1.2±0.6	1.5±0.7	0.033

*EI: endotracheal intubation; **LMA: laryngeal mask anesthesia; ***ASA: American Society of Anesthesiology score.

level was 96.37±1.57 (range: 90 to 98); and post-operative saturation level was 96.721.31 (range: 90 to 98). The average duration of post-operative hospital stay was 44.74±18.49 hours (range: 24 to 96 hours); post-operative care unit stay was 8.81±13.95 hours (range: 0 to 48 hours); and leakage volume was 2.54±2.85 ml (range: 0 to 10 ml).

Comparison of the LMA and EI groups showed no significant differences in patient age, number of surgeries, BMI, head circumference, and ASA score, suggesting homogeneity in both groups. However, the groups did significantly differ in the duration of anesthesia required, need for hospitalization and intensive care stay, time required for airway placement, and number of attempts. LMA was seen to facilitate the peri-operative processes, reduce the need for post-operative intensive care, and shorten the overall length of stay in the hospital (Table 1).

Although the groups did not significantly differ in the incidence of laryngeal spasms, 17.8% of the patients who underwent endotracheal intubation were transferred to the intensive care unit without being extubated. In contrast, none of the patients that underwent LMA required post-operative intubation, and this difference was statistically significant (p=0.007).

During the peri-operative period, no significant differences in saturation levels, mean arterial blood pressure, and peak inspiratory pressure were observed between the groups. Moreover, although the EI group exhibited higher incidence of post-operative laryngeal spasms, this difference was not statistically significant.

Discussion

The management of pediatric patients typically requires more attention, in-depth knowledge, and skills due to their characteristic anatomical, physiological, and pathological features when compared to adults (6). Although the risk of airway-related complications are low in pediatric patients, their occurrence may lead to major peri-operative morbidity and increased risk of mortality (6,7). Anesthesia-related upper airway obstructions frequently occur in pediatric patients (incidence rate: 26%), particularly those with syndromes that cause anatomical deformations in the airway (e.g., Klippel-Feil syndrome, mucopolysaccharidosis, etc.) (8-10). Macrocephaly can obstruct the airways as it leads to disruption of the normal skull anatomy, occiput flexion, and a wide forehead which can obstruct the laryngoscopic view (1,11). The current study evaluated the efficacy of various methods of establishing airways peri-operatively in pediatric patients with hydrocephalus.

The ASA score is the most commonly used method of peri-operative risk evaluation and surgical classification globally, with increasing ASA scores indicating greater risk. Previous studies have reported increased morbidity and mortality in one third of pediatric patients with at least one chronic condition (12). Although hydrocephalus is a chronic disease on its own, the incidence rates of additional congenital (e.g., tetralogy of Fallot, polycystic kidney disease, vertebral anomalies etc.) and developmental pathologies (e.g., scoliosis, neurogenic bladder etc.) is high. In the current study, the most common cause of hydrocephalus was spina bifida, a condition that can not only affect all systems but is also commonly associated with additional pathologies such as chronic kidney disease and respiratory conditions that increase the risk of hospitalization and complications during surgery (13). Restrictive lung diseases that develop as a consequence of scoliosis can reduce total lung capacity and prevent normal ventilation of the lung, thus complicating peri-operative patient management (14). No significant differences in ASA scores and the incidence of additional anomalies were observed by group in the current study, and it should be considered that the perioperative risk of this patient group increased in terms of comorbidity.

V-P shunts are typically associated with a higher risk of complications such as peri-operative infections. These risks can be minimized by shortening the surgical duration, keeping the surgical environment and materials clean, decreasing contact, and reducing the number of entrances to the operating room (15). In this context, no significant differences in terms of surgical duration were observed between the EI and LMA groups, although the total anesthesia time was significantly lower in the latter. Prolonged anesthesia increases the risk of peri-operative hypothermia and coagulopathy, surgical site infection, delayed drug metabolism, transfusion, prolonged recovery, chills, and thermal discomfort (16). As pediatric patients exhibit a tendency towards hypothermia and the presence of macrocephalia in hydrocephalic patients can lead to faster loss of heat through the head, LMA was considered to be more efficient in terms of reducing the risk of peri-operative hypothermia when compared to EI in these patients.

Neuromuscular blockades are widely used during induction of anesthesia to facilitate endotracheal intubation and provide necessary muscle relaxation during surgery (17). Previous evidence suggests that approximately 33-64% of patients who

undergo neuromuscular blockade exhibit insufficient neuromuscular recovery during post-anesthesia care (18). Neuromuscular blockade can cause upper airway obstruction, inadequate respiratory function, decreased pharyngeal muscle coordination, increased risk of aspiration, and impaired hypoxic ventilator response in the early post-operative period (19). However, LMA patients exhibit decreased risk of post-operative respiratory complications as there is no need for the use of muscle relaxants. In the current study, 17.8% of EI patients were sent to the intensive care unit for intubation (8), while none of the LMA patients required intubation after the procedure. Although there was no difference in terms of laryngeal spasm when the LMA was included in the patients intubated in the intensive care unit, laryngeal spasm developed in 14.3% of the EI patients and 5.6% of the patients who underwent LMA, p=0.048, when the intubated patients were excluded. This suggests that the risk of laryngeal spasm is decreased in LMA patients, and this could be attributed to the lower number of attempts required for airway establishment. The two groups did not significantly differ in terms of leakage volume. Polyneuropathy/myopathy, which is closely associated with muscle relaxants, clinically manifests as difficulty in weaning from the mechanical ventilator, severe symmetric muscle weakness, and prolonged stays in the intensive care unit. Recent evidence suggests that this situation, commonly observed in adults, has also been observed in pediatric patients (20).

Decreased hospitalization duration and need for intensive care can increase patient comfort. The findings of this study also suggest that the risk of aspiration can be minimized by using appropriate fasting times and techniques.

Conclusions

The management of hydrocephalus can be challenging for patients, caregivers, and healthcare professionals, and facilitation of the treatment processes can help improve the patient's quality of life. LMA, when used appropriately, can minimize the risk of complications by reducing the need for post-operative intensive care, shortening the length of hospital stay, enabling early nutrition, and reducing the risk of hypothermia in pediatric patients at a higher risk of comorbidities. Moreover, this procedure can also potentially be life-saving during the peri-operative period, particularly in high-risk patients that are difficult to intubate and exhibit higher rates of comorbidities.

Conflict of interest:

The authors report no conflict of interest.

Funding source:

No funding was required.

Ethical approval:

This study was approved by the local Ethics Committee of the University of Health Sciences, Diyarbakir Gazi Yasargil Education and Research Hospital (approval date and number: 13.03.2022/440).

Informed consent:

Patients' consent was obtained.

Acknowledgment:

No

Peer-review:

Externally. Evaluated by independent reviewers working in at least two different institutions appointed by the field editor.

Data availability

All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Contributions

Research concept and design: **EAB, AA**
Data analysis and interpretation: **EAB, AA**
Collection and/or assembly of data: **EAB, AA**
Writing the article: **EAB, AA**
Critical revision of the article: **EAB, AA**
Final approval of the article: **EAB, AA**

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