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RESEARCH ARTICLE

PREDICTIVE FACTORS OF DELAYED POSTOPERATIVE EMERGENCE IN PEDIATRIC ANESTHESIA

Elouardi Khalid,Tissir Abdelhak, Rakrak Amine , Darouich Hasnae, Fakhr Kaoutar and Kalouch Samira

1. Anésthesie Réanimation Pédiatrique; Hospital Abderrahim Harouchi.

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pediatric anesthesia; delayed emergence; postoperative recovery; children; general anesthesia; predictive factors.

Abstract

Background: Delayed postoperative emergence is a clinically relevant complication in pediatric anesthesia. It may prolong post-anesthesia care unit stay, delay transfer to the ward, increase monitoring requirem ents, and, in some cases, lead to admission to intensive care. Children are particularly vulnerable because of their age-related physiological, pharmacological, and psychological specificities.
Objective: The aim of this study was to assess the incidence of delayed postoperative emergence in children undergoing general anesthesia and to identify the factors associated with its occurrence.
Methods: This was a prospective descriptive and analytical study conducted over a six-month period in a pediatric surgery operating room. All children aged from the first day of life to 14 years who underwent surgery under general anesthesia were included. Patients admitted directly to intensive care in the immediate postoperative period were excluded. Demographic, clinical, intraoperative, and posto perative data were collected, including ASA physical status, emergency surgery, medical history, preoperative anxiety or agitation, difficult ven ous access, prolonged operative duration, and post operative complicati ons. Descriptive analysis was followed by univariate and multivariate analyses to identify factors associated with delayed postoperative emergence.
Results:A total of 240 children were included. Male patients represente d 66% of the study population. The mean age was 7.6 years, and the most represented age group was 5 to 12 years. Trauma and visceral surgery were the most frequent surgical indications, accounting for 73.4% of procedures, while 41.5% of interventions were performed in an emergency setting.

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Most patients were classified as ASA I–II. Preoperative anxiety or agitation was observed in 60% of children, and 27.7% had a prolonged operative duration. The incidence of delayed postoperative emergence was 17%. In univariate analysis, emergency surgery, higher ASA status, medical history, difficult venous access, preoperative anxiety or agitation, and prolonged operative duration were significantly associated with delayed emergence. Prolonged operative duration showed the strongest association. In multivariate analysis, emergency surgery,

Corresponding Author:- Elouardi Khalid
Address:-Anésthesie Réanimation Pédiatrique; Hospital Abderrahim Harouchi.

preoperative anxiety or agitation, and prolonged operative duration remained independently associated with delayed postoperative emergence.
Conclusion: Delayed postoperative emergence is a frequent event in pediatric anesthesia. Its occurrence is mainly influenced by emergency surgery, preoperative anxiety or agitation, and prolonged operative duration. Early identification of these factors may help anticipate postoperative risk, optimize anesthetic management, and improve recovery room surveillance.

Introduction:-

Postoperative emergence is a critical phase of anesthesia care. It corresponds to the progressive recovery of consciousness, protective airway reflexes, spontaneous ventilation, and hemodynamic stability after discontinuation of anesthetic agents. In pediatric anesthesia, this period requires particular attention because children present specific physiological and pharmacological characteristics that may influence drug distribution, metabolism, elimination, and recovery.

Delayed postoperative emergence may be defined as a slower-than-expected recovery of consciousness after general anesthesia. Although the exact definition may vary according to institutions and clinical protocols, it generally refers to an abnormal prolongation of the awakening period after the end of anesthesia. In clinical practice, delayed emergence may lead to prolonged monitoring in the post-anesthesia care unit, increased workload for healthcare providers, delayed transfer to the ward, additional investigations, and sometimes intensive care admission.

Several factors may contribute to delayed emergence in children. These include young age, pre-existing medical conditions, high ASA physical status, emergency surgery, prolonged anesthetic exposure, intraoperative complications, hypothermia, residual neuromuscular blockade, opioid or sedative accumulation, metabolic disturbances, and postoperative respiratory or hemodynamic complications. Psychological factors, especially preoperative anxiety and agitation, may also influence anesthetic requirements and the quality of postoperative recovery.

Identifying predictors of delayed postoperative emergence is therefore important in pediatric anesthesia. Early recognition of high-risk patients may allow better preoperative preparation, individualized anesthetic management, appropriate drug titration, prevention of perioperative complications, and optimized postoperative monitoring.
The present study aimed to assess the incidence of delayed postoperative emergence in children undergoing general anesthesia and to identify the factors associated with its occurrence.

Methods:-

Study design and setting:-

This was a prospective, descriptive, and analytical study conducted over a six-month period in a pediatric surgery operating room.

Study population:-

All children aged from the first day of life to 14 years who underwent surgery under general anesthesia during the study period were included. Patients admitted directly to intensive care in the immediate postoperative period were excluded, in order to avoid confusion between delayed emergence and a pre-existing indication for postoperative intensive care.

Collected variables:-

The collected data included demographic, clinical, intraoperative, and postoperative variables:-

- age;
- sex;
- medical history;
- ASA physical status;
- emergency or elective surgery;
- type of surgical procedure;
- preoperative anxiety or agitation;
- difficult venous access;
- prolonged operative duration;
- perioperative events;

- postoperative complications;
- delayed postoperative emergence.

Outcome:-
The main outcome was the occurrence of delayed postoperative emergence after general anesthesia.

Statistical analysis:-
A descriptive analysis was first performed to characterize the study population. Qualitative variables were expressed as numbers and percentages. Quantitative variables were expressed as means or medians according to their distribution. Univariate analysis was then performed to identify factors associated with delayed postoperative emergence. Results were expressed as odds ratios with 95% confidence intervals. A multivariate analysis was subsequently performed to identify independent predictors of delayed emergence. A p-value below 0.05 was considered statistically significant.

Results:-

General characteristics of the study population:-
A total of 240 children were included in the study. Male predominance was observed, with boys accounting for 66% of the population. The mean age was 7.6 years. The most represented age group was 5 to 12 years, accounting for 46.8% of the children. Trauma and visceral surgery were the most common surgical indications, representing 73.4% of procedures. Emergency surgery accounted for 41.5% of cases. Most children were classified as ASA I–II, representing 91.5% of the study population. Preoperative anxiety or agitation was observed in 60% of patients. Prolonged operative duration was reported in 27.7% of children.

Incidence of delayed postoperative emergence:-
Delayed postoperative emergence occurred in 17% of children. This finding highlights the clinical importance of delayed recovery after general anesthesia in pediatric practice.

Univariate analysis:-
In univariate analysis, several factors were significantly associated with delayed postoperative emergence.
Female sex appeared to be associated with a lower risk compared with male sex, with an OR of 0.41, 95% CI 0.28–0.61, and $p < 0.0001$. Emergency surgery was significantly associated with delayed emergence, with an OR of 1.73, 95% CI 1.18–2.53, and $p = 0.005$. Increasing ASA physical status was also significantly associated with delayed emergence, with an OR of 1.95, 95% CI 1.57–2.43, and $p < 0.000000002$. The presence of medical history was associated with an increased risk of delayed emergence, with an OR of 1.88, 95% CI 1.30–2.70, and $p = 0.0008$.
Difficult venous access was significantly associated with delayed emergence, with an OR of 2.33, 95% CI 1.51–3.59, and $p = 0.0001$. Preoperative anxiety or agitation was also associated with delayed emergence, with an OR of 1.65, 95% CI 1.15–2.35, and $p = 0.006$. Prolonged operative duration showed the strongest association with delayed emergence, with an OR of 14.0, 95% CI 7.46–26.27, and $p < 0.00000000000001$.

Multivariate analysis:-
After adjustment in multivariate analysis, three variables remained independently associated with delayed postoperative emergence:-

- emergency surgery;
- preoperative anxiety or agitation;
- prolonged operative duration.

These findings suggest that delayed emergence is not only related to the child's baseline clinical status, but also to the surgical context and perioperative conditions.

Discussion:-

This study found that delayed postoperative emergence occurred in 17% of children undergoing general anesthesia. This incidence confirms that delayed emergence is a frequent postoperative event in pediatric anesthesia and deserves systematic attention in the recovery room. Emergency surgery was one of the main factors associated with delayed emergence. Emergency procedures are often performed in less favorable clinical conditions. Children may present with pain, stress, incomplete fasting, dehydration, trauma, infection, or hemodynamic instability. In addition, preoperative optimization is usually limited in emergency settings. These factors may influence anesthetic management, increase perioperative risk, and contribute to delayed postoperative recovery. Preoperative anxiety or

agitation was also associated with delayed emergence. Anxiety is common in children before surgery and may complicate anesthetic induction. An anxious or agitated child may require higher doses of sedative or hypnotic agents, which can influence recovery time. Moreover, preoperative distress may be associated with postoperative agitation and a more difficult assessment of neurological recovery. These findings support the importance of preoperative psychological preparation, parental presence when possible, child-friendly communication, and appropriate premedication when indicated. Prolonged operative duration was the strongest predictor of delayed emergence. Longer procedures are associated with prolonged exposure to anesthetic agents, opioids, and sometimes neuromuscular blocking drugs. They may also increase the risk of hypothermia, fluid shifts, hemodynamic instability, blood loss, and metabolic disturbances. All these factors can delay the elimination or redistribution of anesthetic drugs and prolong postoperative recovery. Higher ASA physical status, medical history, and difficult venous access were significantly associated with delayed emergence in univariate analysis. These variables reflect the vulnerability of the child and the complexity of perioperative management. However, they did not remain as independent predictors after multivariate adjustment. This suggests that their effect may be partly mediated by other factors such as emergency surgery, operative duration, and perioperative instability.

The association between difficult venous access and delayed emergence may reflect several mechanisms. Difficult vascular access can delay anesthetic management, increase procedural stress, prolong induction time, and may be a marker of more complex perioperative care. However, this association should be interpreted cautiously, particularly because it did not remain an independent factor in multivariate analysis. These findings have practical implications. Children undergoing emergency surgery, anxious or agitated children, and those expected to have prolonged procedures should be considered at higher risk of delayed postoperative emergence. In these patients, anesthetic management should include careful drug titration, prevention of hypothermia, anticipation of postoperative monitoring needs, and early identification of reversible causes of delayed awakening such as hypoventilation, residual neuromuscular blockade, hypoglycemia, electrolyte disorders, hypothermia, or excessive sedative effect.

Clinical implications:-

The results of this study support several practical measures:-

- systematic identification of children at risk before anesthesia;
- improved management of preoperative anxiety;
- careful planning of emergency pediatric anesthesia;
- optimization of anesthetic drug titration during prolonged procedures;
- prevention of hypothermia and metabolic disturbances;
- reinforced monitoring in the post-anesthesia care unit for high-risk patients.

Study limitations:-

This study has some limitations. It was conducted in a single center, which may limit the generalizability of the findings. The exact operational definition of delayed emergence should be standardized to allow comparison with other studies. Detailed pharmacological data, including cumulative doses of hypnotics, opioids, neuromuscular blocking agents, and reversal agents, were not available in the provided results. The use of depth-of-anesthesia monitoring or neuromuscular monitoring was also not specified. Finally, exact adjusted odds ratios from the multivariate model were not available, so the independent predictors were reported qualitatively rather than with precise adjusted estimates.

Conclusion:-

Delayed postoperative emergence is a common complication in pediatric anesthesia, with an incidence of 17% in this study. Emergency surgery, preoperative anxiety or agitation, and prolonged operative duration were identified as independent predictors. Other variables, including higher ASA physical status, medical history, and difficult venous access, were significantly associated with delayed emergence in univariate analysis. Early recognition of these predictive factors may improve perioperative planning, guide anesthetic management, and optimize postoperative surveillance. Preventive strategies should focus on better preparation of children undergoing emergency procedures, reduction of preoperative anxiety, careful titration of anesthetic agents, and close monitoring after prolonged surgery. or activities that could appear to have influenced the submitted work.

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