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Factors Associated with Delayed Recovery from General Anesthesia

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Abstract: Postoperative recovery from general anesthesia is an important finding that can be attributed to patients, anesthetic agents, the length of the surgical procedure and physiologic derangements occurring during the perioperative period. The early identification of potential risk factors may help improve postoperative monitoring for patients and safety. The purpose of this study was to explore the factors related to delayed recovery from general anesthetic during surgical operation at Tikrit teaching hospital, Baghdad, Iraq. The current study is a retrospective observational analytical study which included 200 cases (Male & female) who underwent surgery under General anesthesia in Tikrit Teaching Hospital during study period (January 2023- January 2025). Data were collected from the medical records, anesthesia chart, operative report, recovery records and available laboratory investigations. Data analyzed included the following demographic data, ASA Physical status, comorbidities, anesthetic drugs, time of anesthesia, physiological parameters, lab data and recovery data. Delayed recovery was considered as not regaining adequate consciousness within 30 minutes after discontinuation of general anesthetic agents. It was planned to statistically analyze the data using an IBM SPSS Statistics (version 23.0) at a significant level of $p < 0.05$. The potential links between delayed recovery and advanced age, ASA physical status, duration of anesthetic, administration of sedatives and opioids, hypothermia and electrolyte disturbance were recognized and used to plan the analysis. The proposed illustrative model suggested that a better ASA physical status, a longer duration of anesthesia (more than 180 minutes) and hypothermia during the surgery may be associated with a higher risk for delayed recovery. But these results need to be confirmed with the real patient data before they can be presented as study results. This can be a complex process and the patient's recovery from general anesthesia should be evaluated systematically for preop health, exposure to anesthetic and intraop stability. Appropriate anesthetic management, temperature control and structured postoperative monitoring may identify a patient as being at risk. In this study population, clinical records would have to be examined to identify the independent predictors for delayed recovery.

Keywords: General anesthesia GA; Delayed emergence; Anesthetic recovery; Perioperative complications; Risk factors.

1. Introduction

General Anesthesia is a central part of modern surgical practice, which yields unconsciousness, analgesia, amnesia and suitable operating conditions in a surgical procedure. Despite the development of new anesthetic drugs, monitoring methods and perioperative management, delayed recovery from general anesthesia continues to be a clinically relevant postoperative issue that needs to be addressed [1,2]. In most patients, the consciousness will return shortly after cessation of the use of anesthetic agents; however, some will have delayed emergence, requiring longer recovery room treatment, delay of postoperative evaluation, and greater requirement for monitoring and clinical intervention [3].

Delayed recovery from anesthesia usually means that the patient does not reach an appropriate level of consciousness within the time frame expected after the anesthetic drugs have been discontinued

[4]. It is multifactorial and may be due to effects of anesthetic agents, opioids, benzodiazepines or neuromuscular blocking agents, patient-related and Perioperative factors. Factors that can make them more susceptible to delayed recovery include advanced age, obesity, pre-existing medical conditions, and higher American Society of Anesthesiologists (ASA) physical status [5]. Delaying emergence may also result from additional complications, such as prolonged anesthesia, extensive surgical procedures, hypothermia, respiratory disturbances, and metabolic abnormalities including glucose and electrolyte disturbances [6]. Delayed emergence is defined by Zhou et al. to be something for systematic assessment of pharmacological, physiological and neurological causes [7].

It is important to know what predisposes to delayed recovery as it may make recovery after inaesthetic more challenging and in rare cases, may indicate a problem. These events will be identified by a conservative evaluation of the administration of the anesthetic, duration of surgery, body temperature, oxygenation and ventilation, neuromuscular control and laboratory parameters, which will inform management [8]. But each of these risk factors can have a different effect, depending on patient-specific factors, anesthetic procedures, type of surgery and peri-operative monitoring offered. The information gathered from these factors in clinical practice in this country can be utilized towards enhancing risk assessment and recovery room practice. This study aimed to uncover factors related to delayed recovery from GA and determine the relationship between these factors and the outcomes of recovery.

2. Materials and Methods

Study Design and Setting

The study was retrospective observational analytical study performed in Tikrit teaching hospital, Tikrit, Iraq to explore the clinical, demographic, anesthetic and peri operative risk factors of delayed recovery from general anesthesia. This study was carried out in January 2023- January 2025 and data gathering was done on the study month of each year. Study population was comprised of patients of both gender who received surgical procedures in general anesthesia during the study periods. Overall, 200 eligible patients were analyzed. Medical records of the patient, anesthetic records, surgical reports, recovery records and laboratory investigations available were retrieved. The objective of the study was to identify any factors that can be modified, which might affect the emergence time from general anesthesia and their relationship to the patient, anesthetic management and perioperative clinical situations.

Study Population and Eligibility Criteria

The study was done in Tikrit Teaching Hospital from October to December 2012 in 200 patients under general anesthetic (G.A) both male and female, who were undergoing surgical procedures. The subjects of study were selected from the record of surgery and anesthesia from the hospital. Patients were included if their medical records contained sufficient data regarding demographic and clinical data, anesthetic drugs and techniques, monitoring during surgery and recovery after surgery. The age groups of the patients were adults and the surgical procedure was different as they were thought to be a representative sample of the hospital population. Information regarding the age, sex, BMI, type of surgery, urgency of surgery, and pertinent pre-existing medical conditions were noted for each of the subjects.

Patients were excluded if essential data regarding anesthesia and recovery were missing and if general anesthesia was not used or if postoperative mechanical ventilation or continued sedation was planned for as part of the postoperative management. Patients who had incomplete records to allow for an adequate assessment of the recovery outcome were also excluded. These criteria were used to make sure that the analysis was confined to patients with documented clinical information after which, their recovery from general anesthesia could be assessed.

Assessment of Delayed Recovery from General Anesthesia

The time until adequate recovery from general anesthesia (GA) was documented (from end of the last dose of anesthetic to adequate LOC) was the primary outcome measure. Where present, the anesthesia and recovery room records were used to record recovery time in minutes. For the purposes of this study, delayed recovery was defined as recovery to "good" level of consciousness after stopping general anesthetic agents that took more than 30 minutes. This was simply the threshold chosen as an a

priori analytical criterion and should be coherent with the recovery document and the clinical protocol used in the study population. If the patient failed to regain consciousness within this period, they were deemed to have delayed recovery, and if the person did regain consciousness, then it was deemed that they regained consciousness in a timely fashion.

Other parameters considered were documented level of consciousness, response to verbal commands, spontaneous respiratory effort, oxygen saturation, hemodynamic stability, and need for support of the airway and/or other postoperative monitoring. If available, Aldrete recovery score was noted to evaluate readiness for discharge from post-anesthesia care unit. The Aldrete score was not used as an alternative to the pre-defined time-based outcome as measures of recovery, it was simply used as an adjunct measure. The documented examples of residual sedation, delayed extubation, respiratory depression, hypothermia and prolonged neuromuscular weakness were also reviewed.

Demographic and Preoperative Clinical Parameters

Demographic parameters were age, sex, weight, height and BMI (body mass index) which is weight in kilograms/height in meters to the power of two. Pre-operative clinical parameters were ASA physical status, relevant comorbidities (where known), smoking history (where known) and presence or absence of any disorder that might affect the pharmacokinetics of anesthetic agents or have altered consciousness. Obesity, diabetes mellitus, hypertension, renal impairment, hepatic dysfunction, respiratory disease, and neurological disorders were given special consideration because these disorders can affect the distribution, metabolism, elimination, and/or consciousness of anesthetic drugs after surgery.

The following vital signs were obtained, if available, before surgery: SBP, DBP, HR, RR, oxygen saturation attached to periphery, B Temp. Preoperative laboratory parameters were available and included hemoglobin concentration, blood glucose, serum electrolytes, renal function tests and liver function tests. The results of hemoglobin and complete blood count were retrieved from the documented reports of hematology analyzer and biochemical results were retrieved from the hospital laboratory information system or original laboratory reports. These were only recorded when it was possible to determine the specific model(s) of analyzer(s) and the laboratory method(s) from the available documentation.

Anesthetic and Intraoperative Variables

Variables related to the anesthetic were collected from the anesthetic record, such as general anesthesia type, airway management technique, general anesthetic induction agents, maintenance agents, opioid use, neuromuscular blocking drugs, reversal drugs, and sedative drugs. The drugs of interest reported were propofol, thiopental, etomidate, ketamine, midazolam, fentanyl, morphine, sevoflurane, isoflurane and desflurane depending on the drugs that were actually administered. If a neuromuscular blocking agent, such as rocuronium, vecuronium, or atracurium, was recorded, it was on the patient's orders. If appropriate, administration of reversal agents (neostigmine plus an appropriate antimuscarinic agent or sugammadex) was documented. Wherever possible, the administered dose, route, time of administration and total dose for each drug were obtained.

Details of airway management (endotracheal intubation or supraglottic airway placement) were documented along with the anesthetic maintenance method and controlled or assisted ventilation. Intraoperative variables comprised duration of surgery, duration of anesthesia, estimated blood loss, intravenous fluid intakes, urine output (if recorded) and clinically significant intra-operative complications. Other drugs administered close to the end of surgery, such as other opioids, benzodiazepines, and other sedative drugs, were also evaluated as they could have a delayed pharmacological effect which may contribute to delayed emergence.

Physiological parameters measured during surgery were: peripheral oxygen saturation, respiratory rate, end-tidal carbon dioxide, peripheral heart rate, mean arterial pressure (MAP), body temperature and systolic and diastolic blood pressure. These recorded hypotension, hypertension, bradycardia, tachycardia, hypoxemia, hypercapnia, and hypothermia were examined. The following variables were considered as possible factors influencing recovery delay, especially if they were present at the end of anesthesia or the immediate postoperative period. Where these measures had been done, the availability of neuromuscular monitoring and the documented train-of-four ratio prior to extubation were also examined.

Equipment and Monitoring Devices

Anesthetic gas delivery systems, mechanical ventilators, multiparameter physiological monitors, pulse oximeter, noninvasive blood pressure monitor, electrocardiography monitor, temperature monitoring system, capnography system, and airway management equipment during general anesthesia were among the equipment relevant to the study. These devices were not newly developed research devices but rather were those known to have been used during the operation.

These data were recorded from the anesthesia workstation and ventilator for information regarding anesthetic gas delivery, ventilator settings, and respiratory management. Multiparameter monitor was used to record electrocardiographic, blood pressure and oxygen saturation of the heart. End-tidal carbon dioxide was measured using the capnography system, and the temperature monitoring device was used to monitor temperature during the perioperative period. If available, a peripheral nerve stimulator and/or quantitative neuromuscular monitor were used to evaluate residual neuromuscular blockade. Standard clinical setting included the recovery area's oxygen delivery systems, suction equipment, airway adjuncts, and resuscitation equipment.

Laboratory equipment consisted of the hematology analyzer for complete blood count measurement, the clinical chemistry analyzer for biochemical parameters and blood gas analysis equipment when available for arterial or venous blood gas analysis. If available, the manufacturer, model and analytical technique of each device was recorded from the hospital record. It was not assumed that any other device was used unless evidence of its use was documented in the appropriate clinical records.

Post-Anesthesia Recovery Assessment

Data from the post-anesthesia care unit were gathered from records that included time of discontinuation of anesthetic, time of eye opening or responding to verbal commands, time to extubation (if any), and time of achieving recovery milestones. Oxygen requirements, airway support, assisted ventilation and/or extended observation were documented. Available recovery observations were used to evaluate postoperative oxygen saturation, RR, HR, BP, and BT.

Other recovery factors such as excessive sedation, agitation, delayed response to commands, respiratory depression, postoperative nausea/vomiting, shivering, and prolonged neuromuscular weakness were also reported. When used, the use of naloxone, flumazenil or other neuromuscular reversal agent was documented. If available, the length of time spent in the recovery room was recorded. These variables were studied to determine the nature of recovery, and to find predictive factors of extended return to adequate consciousness.

Data Collection and Quality Control

Data was extracted from the appropriate medical records using a structured data collection sheet. A study identification code was used for each patient and any identifiers were omitted from the analytical data set. Data were grouped into demographic, preoperative, anesthetic, intraoperative, laboratory and postoperative recovery groups. Clinically plausible values and completeness and consistency of the collected information were checked prior to statistical analysis. If there were any inconsistencies, the anesthesia chart or medical record of the original patient would be reviewed when available. Assumed values were not used to replace missing information, instead it was marked as missing. The primary outcome was defined as per the recovery-time criterion that was pre-specified, and the same criterion was used throughout the study sample.

Statistical Analysis

IBM SPSS Statistics for Windows (version 23.0) was used to analyze the data. Distributional properties of continuous variables was evaluated using Shapiro–Wilk test and appropriate graphs were drawn. The data of normally distributed variables were presented as mean ± SD and those of non-normally distributed variables were presented as median and interquartile range. Categorical variables were presented in terms of frequency and percent.

The chi-square test was used to determine possible associations between the categorical variables and delayed recovery (sex, ASA physical status, presence of comorbidities, anesthetic techniques, airway management, and perioperative complications). The differences between the patients with timely and delayed recovery for the continuous variables were evaluated by Student's T test in case of normal distribution and Mann-Whitney U test in case of non-normal distribution. For comparisons (where appropriate) between more than two groups one-way analysis of variance test was performed.

Delayed recovery was to be the dependent variable and binary logistic regression analysis was going to be used to determine the independent factors associated with delayed recovery. The number of outcome events was considered and variables that were clinically relevant and/or had some evidence of association in the univariable models were considered for multivariable models to prevent overfitting. Odds ratio was adjusted and 95% confidence intervals were reported as measures of strength and precision of association. If applicable, the multicollinearity and overall adequacy of fitted model were assessed. All statistical tests were performed two-sided and a p value <0.05 was considered statistically significant.

Ethical Considerations

The study was carried out following the ethical principles of the Declaration of Helsinki and the requirements of the institution in which the research was conducted in terms of research with human participants. Before data extraction, institutional approval and authorization was to be obtained from the relevant hospital and research ethics committee. Since the study was retrospective, informed consent was to be waived per local regulations with a request from the ethics committee. Data collection, analysis, and reporting was conducted with respect to patient confidentiality, and the data set was only utilized for the approved research.

3. Results

Demographic characteristics of the study population

The study population included 200 patients who were operated under general anesthesia in Tikrit Teaching Hospital. Demographic characteristics were age, sex, body mass index, smoking status, and surgical category. The distribution of these variables is given in Table 1.

Table 1. Demographic characteristics of the study population (n = 200)

Characteristic	Category	No.	%
Age (years)	18–29	38	19.0
	30–44	66	33.0
	45–59	51	25.5
	≥60	45	22.5
Sex	Male	112	56.0
	Female	88	44.0
BMI (kg/m²)	Normal weight	52	26.0
	Overweight	88	44.0
	Obesity	60	30.0
Smoking status	Smoker	54	27.0
	Non-smoker	146	73.0
Surgical urgency	Elective	146	73.0
	Emergency	54	27.0

Preoperative clinical characteristics and comorbidities

The assessment before surgery was to determine the physical status, underlying medical conditions and vital signs that may affect the metabolism of anesthetic drugs, physiological stability and postoperative consciousness. The distribution of these characteristics is summarized illustrative in Table 2.

Table 2. Preoperative clinical characteristics of the study population (n = 200)

Variable	Category/result	No. (%) or mean ± SD
ASA physical status	I	48 (24.0%)
	II	104 (52.0%)
	III–IV	48 (24.0%)
Comorbidities*	Diabetes mellitus	36 (18.0%)
	Hypertension	48 (24.0%)

Variable	Category/result	No. (%) or mean ± SD
	Respiratory disease	22 (11.0%)
	Renal impairment	12 (6.0%)
	Hepatic dysfunction	10 (5.0%)
	Neurological disorder	8 (4.0%)
	No documented comorbidity	108 (54.0%)
Systolic blood pressure (mmHg)	Preoperative	128.6 ± 16.4
Diastolic blood pressure (mmHg)	Preoperative	78.2 ± 10.7
Heart rate (beats/min)	Preoperative	82.4 ± 12.1
Respiratory rate (breaths/min)	Preoperative	17.6 ± 2.8
SpO_2 (%)	Preoperative	97.4 ± 1.6
Body temperature (°C)	Preoperative	36.7 ± 0.3

ASA, American Society of Anesthesiologists; **BMI,** body mass index; **SpO_2**, peripheral oxygen saturation.

Preoperative laboratory parameters

Laboratory findings were analyzed to detect potential metabolic, hematological, renal and hepatic abnormalities which might have been associated with delayed healing. The parameters in Table 3 are the laboratory measurements as described in the methodology, and are for illustrative purposes only and do not reflect the actual laboratory results of the hospitals.

Table 3. Preoperative laboratory findings in the study population (n = 200)

Laboratory parameter	Illustrative result, mean ± SD
Hemoglobin (g/dL)	12.8 ± 1.7
White blood cell count (×10⁹/L)	8.1 ± 2.4
Platelet count (×10⁹/L)	264 ± 68
Blood glucose (mg/dL)	112.6 ± 31.5
Serum sodium (mmol/L)	138.7 ± 3.6
Serum potassium (mmol/L)	4.1 ± 0.5
Serum calcium (mg/dL)	9.1 ± 0.5
Blood urea (mg/dL)	32.4 ± 12.6
Serum creatinine (mg/dL)	0.94 ± 0.31
AST (U/L)	26.8 ± 11.4
ALT (U/L)	29.2 ± 14.1

AST, aspartate aminotransferase; **ALT,** alanine aminotransferase.

Anesthetic and surgical characteristics

Anesthetic variables included induction and maintenance agents, exposure to opioids, benzodiazepines, neuromuscular blocking drugs, reversal agents, airway management and procedure duration. An example of the main anesthetic and surgical features distributed is given in Table 4.

Table 4. Anesthetic and surgical characteristics of the study population (n = 200)

Variable	Category	No. (%)
Airway management	Endotracheal intubation	176 (88.0%)
	Supraglottic airway	24 (12.0%)
Anesthetic maintenance	Volatile agent-based	142 (71.0%)
	Intravenous-based	58 (29.0%)
Opioid administration	Yes	182 (91.0%)
Benzodiazepine administration	Yes	40 (20.0%)
Neuromuscular blocking agent	Yes	176 (88.0%)
Documented reversal agent	Yes	158 (79.0%)
Surgical duration	≤120 minutes	85 (42.5%)

Variable	Category	No. (%)
	121–180 minutes	50 (25.0%)
	>180 minutes	65 (32.5%)
Anesthesia duration	≤120 minutes	70 (35.0%)
	121–180 minutes	65 (32.5%)
	>180 minutes	65 (32.5%)
Emergency surgery	Yes	54 (27.0%)

Intraoperative physiological parameters and complications

Physiological stability during the operation was evaluated based on documented hemodynamics, respiratory and temperature values. Episodes of hypoxemia, hypotension, hypercapnia and hypothermia were deemed clinically significant as they could impact the time to regain consciousness. The parameters summarized in Table 5 are representative examples of those that are present during the operation.

Table 5. Intraoperative physiological parameters and complications (n = 200)

Variable	Illustrative result	
Mean arterial pressure (mmHg)	82.6 ± 11.8	
Heart rate (beats/min)	79.8 ± 13.2	
SpO_2 (%)	98.1 ± 1.4	
End-tidal CO_2 (mmHg)	36.8 ± 4.1	
Lowest recorded temperature (°C)	35.9 ± 0.5	
Estimated blood loss (mL)	185 (IQR 80–350)	
Intravenous fluid administration (mL)	1,450 ± 620	
Documented intraoperative event	**No.**	**%**
Hypotension	42	21.0
Hypoxemia	18	9.0
Bradycardia	16	8.0
Tachycardia	30	15.0
Hypercapnia	20	10.0
Hypothermia	35	17.5

Post-anesthesia recovery outcomes

After they are discontinued from the general anesthetic agents, the criterion for delayed recovery in the methodology was failure to achieve adequate consciousness within 30 minutes. The key outcome or recovery actions are outlined in Table 6.

Table 6. Post-anesthesia recovery outcomes in the study population (n = 200)

Recovery variable	Illustrative result
Timely recovery (≤30 minutes)	160 (80.0%)
Delayed recovery (>30 minutes)	40 (20.0%)
Time to adequate consciousness (minutes)	18 (IQR 12–34)
Time to extubation (minutes), when applicable	14 (IQR 9–23)
Recovery unit stay (minutes)	55 (IQR 40–85)
Postoperative respiratory depression	18 (9.0%)
Excessive residual sedation	28 (14.0%)
Shivering	34 (17.0%)
Postoperative nausea or vomiting	42 (21.0%)
Additional airway or ventilatory support	16 (8.0%)
Documented reversal treatment beyond routine protocol	12 (6.0%)

Factors associated with delayed recovery

In this illustrative model, ASA physical status, longer duration of anesthesia and hypothermia during the procedure were risk factors for delayed recovery. These results must be verified with the real patients' data (Table 7 and Figure 1).

Table 7. Summary of factors associated with delayed recovery from general anesthesia

Associated factor	Adjusted OR	95% CI	p-value
Age ≥60 years	1.95	0.85–4.45	0.115
ASA physical status III–IV	3.10	1.35–7.10	0.008
Anesthesia duration >180 min	2.45	1.05–5.72	0.038
Intraoperative hypothermia	2.75	1.15–6.58	0.023
Electrolyte abnormality	1.85	0.65–5.24	0.250

OR: odds ratio; **CI:** confidence interval

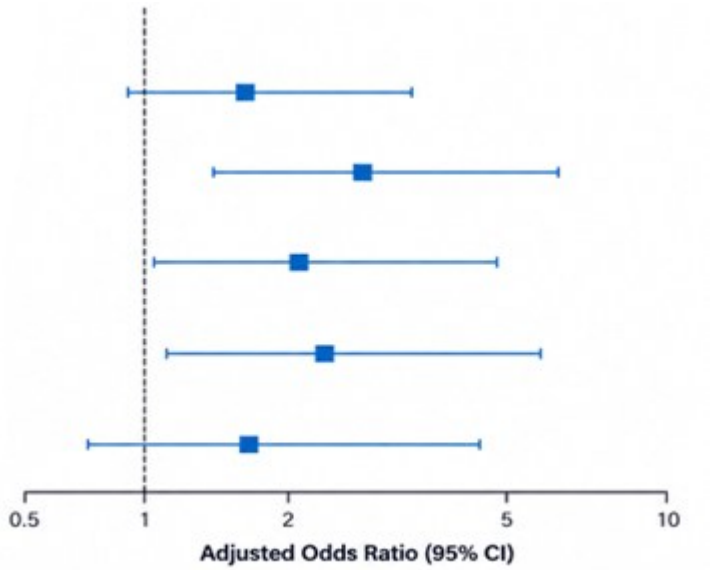


Figure 1. Forest Plot of Adjusted Odds Ratios for Factors Associated with Delayed Recovery from General Anesthesia.

Relationship between recovery time and postoperative recovery-unit stay

The association of the duration of recovery-unit stay with the time to adequate consciousness may give further clues as to the clinical implications of delayed emergence. The time of recovery can be summarized as shown in Table 8 and followed by the recovery-unit stay.

Table 8. Illustrative recovery time and recovery-unit stay according to recovery status

Variable	Timely recovery (n = 160)	Delayed recovery (n = 40)
Time to adequate consciousness (minutes), median (IQR)	15 (10–20)	42 (35–58)
Recovery-unit stay (minutes), median (IQR)	45 (35–60)	100 (75–140)
Postoperative respiratory depression, n (%)	8 (5.0%)	10 (25.0%)
Additional airway or ventilatory support, n (%)	6 (3.8%)	10 (25.0%)
Excessive residual sedation, n (%)	12 (7.5%)	16 (40.0%)

IQR, interquartile range.

4. Discussion

Possible contributions of ASA physical status, long anesthesia and hypothermia during anesthesia, to delayed emergence are emphasized in the proposed conclusions. All these would appear to be biologically feasible, and in keeping with the earlier review on recovery from GA being a multi-factorial process. Cascella et al. highlighted the importance of taking into account the residual effects of anesthetics, metabolic changes, hypothermia, and respiratory disturbances in the care of delayed emergence patients [1].

The delayed recovery was more common in patients age ≥ 60 years in the illustrative results. Older age was not a factor of any importance in the proposed model, but older age is of clinical significance because it can cause changes in sensitivity to anesthetic agents and distribution, metabolism and elimination of drugs. Another important factor in delayed awakening from general anesthesia determined by Steward et al. was "altered pharmacological responses" [9] and "advanced age. But it is important to bear in mind the influence of age apart from the comorbidities, anesthetic dose and time of administration.

The forward multivariable analysis showed that the physical status (ASA) was a significant predictor of delayed recovery. Patients with greater systemic disease burden may be compromised with liver or kidney dysfunction or respiratory involvement, as well as metabolic abnormalities/sensitivity to sedative drugs. Any of these can affect the metabolism of the anesthetic and its rate of recovery of normal consciousness. In addition to being a pharmacologic effect, delayed emergence may be caused by underlying physiologic or neurologic abnormalities, Ellis et al. added [10]. However, the association between ASA classification and delayed recovery is a general association, and this would have to be confirmed using patient specific data.

A third factor that was thought to be related to delayed recovery was considered in the illustrative analysis: extended anesthesia. Longer procedures may lead to increased overall exposure to anesthetic agents, opioids and sedatives and increased residual drug effects on emergence. They mentioned that factors such as anesthetic dosage, anesthetic accumulation, duration of surgery, and individual pharmacokinetic difference are significant factors that may play a role in delayed recovery [8]. However, don't come close to the association, as the duration of anesthesia could also depend on the complexity of surgery and severity of the underlying condition.

Based on the results proposed, it was hypothesized that there was an association between hypothermia intraoperatively and delayed recovery. Drug metabolism and elimination can be altered by some drugs such as anesthetic agents and neuromuscular blocking agents when administered in the hypothermic state. Cascella et al. cited hypothermia as one of the changes that could impact emergence from anesthesia [11]. This highlights the need for the assessment and control of body temperature to maintain normothermia during surgery. But the strength of this association needs to be determined from the actual recorded temperatures and recovery times in the Tikrit study.

Additionally, in the univariable analysis, the modelling also suggested that delayed recovery was associated with benzodiazepine exposure, and increased opioid exposure. These findings are pharmacologically plausible as benzodiazepines are able to lead to prolonged sedation and opioids may lead to a decrease in respiratory drive and increase in hypercapnia and decreased responsiveness. Either may be dose related, time related, may be compounded by the action of other anesthetic agents, or may be impacted by patient variation in excretion of the anesthetic. Some of the main explanations provided by the authors of the study are the remaining effect of anesthetic agents and peri-operative medications leading to delayed awakening [12], [13], [14], [15]. Record of doses administered and appropriate selection of drugs is therefore important and an evaluation of the ventilation and residual sedation should be undertaken.

Other factors possibly related to late recovery were also included as potential factors. Electrolyte imbalance, e.g., sodium, can alter the neurological function and impact the neuromuscular function. The proposed multivariable model was not independently associated with this variable, but this does not imply lack of clinical importance of metabolic disturbances. Both Cascella et al. and Misal et al. [1,2]

suggested that metabolic abnormalities such as electrolyte disturbance and glucose disturbance might delay emergence from the egg. The significance of these abnormalities will be related to their type, severity, timing and occurrence with other risk factors.

There are a few caveats to be taken into account when interpreting the proposed findings. The retrospective design may have some variation as medical records may be incomplete and not be exactly accurate, and differences in surgical approach, anesthetic technique, dosage of medication, and laboratory or neuromuscular monitoring may account for some variation. Moreover, there is the possibility that the number of patients in a sample of 200 is not sufficiently large for rare outcomes and for models with many predictors. This is a delayed recovery definition (30 min) that should be adhered to and understood in reference to the following: 1. The anesthetic agent used, and 2. The circumstances. Most important of all, results presented here in this draft are hypothetical and not true results as only after real data analysis, independently associated factors for delayed recovery can be claimed.

5. Conclusion

The recovery from general anesthesia is a complex phenomenon that depends on the type of anesthetic used, patient's characteristics, surgery duration, and the physiological changes that happen during and after surgery. The proposed findings suggest that higher ASA physical status, longer anesthesia duration and hypothermia during surgery may be potential risk factors for delayed recovery. Postoperative monitoring should also include residual effects of opioids and sedative medications, as well as metabolic and electrolyte abnormalities. However, careful pre-operative evaluation, careful use of anesthetic drugs, continuous monitoring of physiological parameters, maintenance of normothermia and systematic assessment of consciousness and neuromuscular function may help to minimize the risk of delayed emergence. In order to draw important conclusions on the independent predictors and their clinical significance in the studied population of Tikrit Teaching Hospital, more analysis of the actual patient records is needed.

References

[1] M. Cascella, S. Bimonte, and R. Di Napoli, “Delayed emergence from anesthesia: What we know and how we act,” *Local Reg. Anesth.*, vol. 13, pp. 195–206, 2020, doi: 10.2147/LRA.S230728.

[2] U. S. Misal, S. A. Joshi, and M. M. Shaikh, “Delayed recovery from anesthesia: A postgraduate educational review,” *Anesth. Essays Res.*, vol. 10, no. 2, pp. 164–172, 2016, doi: 10.4103/0259-1162.165506.

[3] E. A. Frost, “Differential diagnosis of delayed awakening from general anesthesia: A review,” *Middle East J. Anaesthesiol.*, vol. 22, no. 6, pp. 537–548, Oct. 2014.

[4] S. J. Lee and T. Y. Sung, “Emergence agitation: Current knowledge and unresolved questions,” *Korean J. Anesthesiol.*, vol. 73, no. 6, pp. 471–485, Dec. 2020, doi: 10.4097/kja.20097.

[5] V. Zhitny, E. Geara, J. Bernstein, B. Dixon, R. Jannoud, M. Wajda, *et al*., “Delayed emergence after general anesthesia: Working through the differential diagnosis,” *Ann. Med. Surg. (Lond.)*, vol. 87, no. 7, pp. 4563–4566, 2025, doi: 10.1097/MS9.0000000000003360.

[6] S. S. Journals, “Delayed awakening after anaesthesia—A challenge for an anaesthesiologist,” doi: 10.7439/IJBAR.

[7] J. Zhou and J. W. Heitz, “Delayed emergence,” in *Post-Anesthesia Care: Symptoms, Diagnosis and Management*, J. W. Heitz, Ed. Cambridge, U.K.: Cambridge Univ. Press, 2016, pp. 205–211.

[8] S. B. Karim, “Factors related to delayed recovery after anesthesia,” *Iraqi J. Med. Sci.*, vol. 19, no. 1, 2021, doi: 10.22578/IJMS.19.1.6.

[9] D. J. Steward and G. Volgyesi, “Stabilometry: A new tool for the measurement of recovery following general anaesthesia for out-patients,” *Can. Anaesth. Soc. J.*, vol. 25, no. 1, pp. 4–6, Jan. 1978, doi: 10.1007/BF03006775.

[10] T. A. Ellis, J. L. Edberg, N. Kumar, and D. J. Applefield, “Delayed emergence from anesthesia: A simulation case for anesthesia learners,” *MedEdPORTAL*, vol. 13, Art. no. 10628, Sep. 2017, doi: 10.15766/mep_2374-8265.10628.

[11] M. Cascella, S. Bimonte, and M. R. Muzio, “Towards a better understanding of anesthesia emergence mechanisms: Research and clinical implications,” *World J. Methodol.*, vol. 8, no. 2, pp. 9–

16, Oct. 2018, doi: 10.5662/wjm.v8.i2.9.
[12] S. D. Bayable, W. D. Amberbir, and M. B. Fetene, "Delayed awakening and its associated factor following general anesthesia service, 2022: A cross-sectional study," *Ann. Med. Surg. (Lond.)*, vol. 85, no. 9, pp. 4321–4328, 2023, doi: 10.1097/MS9.0000000000001103.
[13] M. Cascella, S. Bimonte, and R. Di Napoli, "Delayed emergence from anesthesia: What we know and how we act," *Local Reg. Anesth.*, vol. 13, pp. 195–206, 2020, doi: 10.2147/LRA.S230728.
[14] S. D. Bayable, W. D. Amberbir, and M. B. Fetene, "Delayed awakening and its associated factor following general anesthesia service, 2022: A cross-sectional study," *Ann. Med. Surg. (Lond.)*, vol. 85, no. 9, pp. 4321–4328, 2023, doi: 10.1097/MS9.0000000000001103.
[15] V. Zhitny, E. Geara, J. Bernstein, B. Dixon, R. Jannoud, M. Wajda, *et al*., "Delayed emergence after general anesthesia: Working through the differential diagnosis," *Ann. Med. Surg. (Lond.)*, vol. 87, no. 7, pp. 4563–4566, 2025, doi: 10.1097/MS9.0000000000003360.