



FACTORS ASSOCIATED WITH DELAYED RECOVERY FROM ANAESTHESIA: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract:

Background: Delayed Recovery From Anaesthesia Is A Common Postoperative Concern That Can Prolong Monitoring Time, Disrupt Perioperative Workflow, And Increase Healthcare Costs. Despite Improvements In Anaesthetic Drugs And Monitoring Techniques, Some Patients Continue To Experience Slower-Than-Expected Awakening. Understanding The Factors That Contribute To Delayed Recovery Is Essential For Improving Patient Safety And Postoperative Efficiency. This Study Was Done To Identify Clinical And Perioperative Factors Associated With Delayed Recovery From Anaesthesia In Adult Surgical Patients.

Methods: This Observational Study Included 240 Adult Patients Undergoing Elective Surgeries Under General Anaesthesia. Data Were Collected On Demographic Characteristics, Comorbidities, Duration Of Surgery, Anaesthetic Drugs, And Intraoperative Opioid Use. Recovery Time Was Assessed In The Postoperative Period, And Patients Who Needed Longer Than Expected To Regain Full Consciousness Were Classified As Having Delayed Recovery. Multivariate Logistic Regression Was Used To Determine Independent Predictors.

Results: Delayed Recovery Was More Frequently Observed In Patients Aged Over 60 Years. Surgeries Lasting More Than Two Hours Showed A Significantly Higher Likelihood Of Prolonged Awakening. Increased Intraoperative Opioid Requirements Were Also Strongly Associated With Delayed Recovery. These Factors Remained Significant Independent Predictors Even After Adjusting For Other Perioperative Variables.

Conclusion: Delayed Recovery From Anaesthesia Is Influenced By A Combination Of Patient Characteristics And Intraoperative Management. Age Above 60 Years, Longer Surgical Procedures, And Higher Opioid Doses Emerged As Significant Predictors. Recognising These Risk Factors Early Allows Clinicians To Individualise Anaesthetic Plans, Adopt Opioid-Sparing Strategies, And Ensure Closer Postoperative Monitoring For High-Risk Patients. Such Measures Can Enhance Patient Safety And Contribute To Smoother Postoperative Care And Improved Outcomes.

Keywords: Delayed Recovery, Anaesthesia, Postoperative Awakening, Opioids, Elderly Patients Etc.

Introduction:

Recovery From Anaesthesia Is An Essential Phase Of Perioperative Care, Reflecting The Return Of Consciousness, Airway Protection, Physiological Stability, And Adequate Neuromuscular Function. With The Use Of Modern, Short-Acting Anaesthetic Agents, Most Patients Are Expected To Wake Promptly After Surgery. However, Delayed Recovery Is Still Encountered In Routine Clinical Practice And Remains A Matter Of Concern For Anaesthesiologists. It Can Lead To Prolonged Stays In The Post-Anaesthesia Care Unit (Pacu), Delay Postoperative Assessment, And Increase The Risk Of Respiratory Compromise, Aspiration, Or Neurological Complications.^{1,2}

The Causes Of Delayed Recovery Are Often Multifactorial. Pharmacological Influences Are Among The Most Frequent Contributors, Especially The Residual Effects Of Benzodiazepines, Opioids, Volatile Agents, And Neuromuscular Blocking Drugs.^{3,4} Patient-Related Characteristics Including Advanced Age, Obesity, Hepatic Or Renal Impairment, Endocrine Abnormalities, And Chronic Medication Use May Also Affect Drug Metabolism And Clearance, Thereby Prolonging Emergence.^{5,6} Surgical Factors Such As Lengthy Procedures, Major Operations, And Intraoperative Haemodynamic Fluctuations Add Further Complexity. Inadequate Reversal Of Neuromuscular Blockade, Perioperative Hypothermia, And Metabolic Disturbances Such As Hypoglycaemia Or Electrolyte Imbalance Are Also Well-Recognised Contributors.^{7,8}

Identifying These Factors Before Surgery Allows For More Individualised Anaesthetic Plans, Careful Titration Of Drugs, And Enhanced Intraoperative Monitoring. Although Several Studies Have Explored Delayed Emergence, The Influencing Factors Vary Across Populations, Types Of Anaesthesia, And Institutional Practices. Local Data Are Therefore Valuable For Better Understanding Patterns Within Specific Clinical Settings And For Refining Strategies To Improve Patient Safety And Optimise Pacu Utilisation.

This Prospective Observational Study Aims To Evaluate The Factors Associated With Delayed Recovery From Anaesthesia Among Patients Undergoing Various Surgical Procedures At Our Centre. By Examining Clinical Variables, Anaesthetic Techniques, And Intraoperative Events, The Study Seeks To Identify Key Predictors That May Guide More Efficient And Safer Perioperative Management.

Material And Methods:

This Study Was Designed As A Prospective Observational Study And Was Conducted In The Department Of Anaesthesiology At World College Of Medical Sciences And Research, Gurawar, Jhajjar, Haryana. The Study Period Was 1 Year, From August 2024 To August 2025 Covering Both Elective And Emergency Surgical Procedures Performed Under General Anaesthesia. All Adult Patients Aged 18–70 Years Undergoing Surgery Under General Anaesthesia During The Study Period Were Screened For Eligibility. Patients Were Included If They Received Standard General Anaesthesia With Airway Management (Endotracheal Intubation Or Supraglottic Device) And Were Transferred To The Post-Anaesthesia Care Unit (Pacu) For Recovery. Patients With Pre-Existing Neurological Disorders, Psychiatric Illness, Severe Hepatic Or Renal Failure, Chronic Use Of Sedative Or Antiepileptic Medications, Anticipated Postoperative Ventilation, Or Procedures Requiring Prolonged Sedation Or Icu Care Were Excluded. A Total Of 240 Patients Meeting The Inclusion Criteria Were Enrolled Consecutively During The Study Period. Preoperative Data Including Age, Sex, Bmi, Comorbidities, Medication History, And Relevant Laboratory Values Were Recorded. Intraoperative Information Such As Anaesthetic Drugs Used, Types & Duration Of Surgery, Blood Loss, Intraoperative Temperature, Haemodynamic Fluctuations, And Neuromuscular Blocker Usage Were Documented. Adequacy Of Neuromuscular Reversal And Extubation Criteria Were Also Noted. Recovery Was Evaluated In The Pacu Using Standard Clinical Criteria. Delayed Recovery Was Defined As Failure To Achieve A Modified Aldrete Score ≥ 9 Within 30 Minutes Of Arrival In The Pacu, Or Persistent Sedation Requiring Extended Monitoring Beyond Expected Recovery Time. The Primary Outcome Was The Occurrence Of Delayed Recovery From Anaesthesia. Secondary Outcomes Included Identification Of Patient-Related, Drug-Related, And Intraoperative Factors Associated With Delayed Recovery. Data Were

Entered Into Microsoft Excel And Analysed Using Spss Version 20. Categorical Variables Were Compared Using The Chi-Square Test. Continuous Variables Were Analysed With Independent T-Tests. Multivariate Logistic Regression Was Performed To Identify Independent Predictors Of Delayed Recovery. A P-Value < 0.05 Was Considered Statistically Significant.

Results:

A Total Of 240 Patients Undergoing Elective Surgery Under General Anaesthesia Were Included In This Prospective Observational Study. The Overall Incidence Of Delayed Recovery Was 18.8% (45 Patients).

Table 1 Summarises The Baseline Demographic And Clinical Characteristics Of The 240 Patients Included In The Study. The Mean Age Of The Study Population Was 47.2 ± 12.6 Years, Indicating That Most Participants Were Middle-Aged Adults. Females Constituted A Slightly Higher Proportion (57.5%) Compared To Males (42.5%). The Average Body Mass Index (Bmi) Was 25.1 Kg/M^2 , Placing The Group In The Upper Range Of Normal To Mildly Overweight.

Table 1: Baseline Demographic Characteristics Of Study Participants (N = 240)

Parameter	Mean $\pm$ Sd / N (%)
Age (Years)	47.2 ± 12.6
Male : Female	102 (42.5%) : 138 (57.5%)
Bmi (Kg/M^2)	25.1 ± 3.7

Regarding Comorbidities (Figure 1), Hypertension (28.3%) Was The Most Common Associated Condition, Followed By Diabetes Mellitus (21.7%) And Hypothyroidism (14.6%). About One-Third Of The Patients (35.4%) Did Not Have Any Significant Comorbidity. These Baseline Characteristics Reflect A Typical Tertiary-Care Surgical Population, With A Moderate Prevalence Of Chronic Medical Conditions That Could Potentially Influence Anaesthetic Recovery.

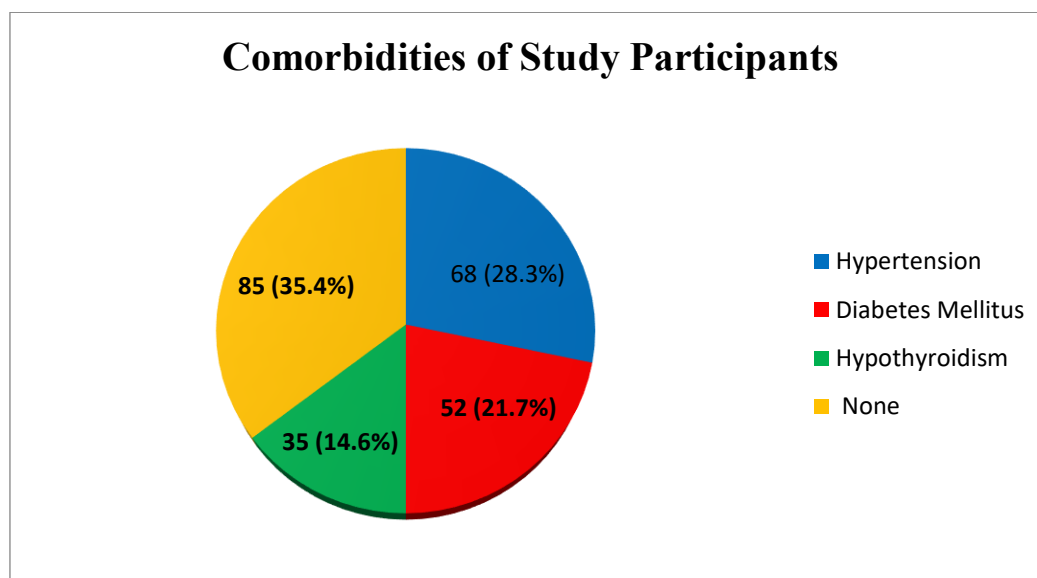


Figure 1: Comorbidities Of Study Participants

Table 2 Summarises The Key Intraoperative Anaesthetic And Surgical Variables That May Influence Postoperative Recovery. The Average Duration Of Surgery Was Approximately 96 Minutes, Indicating That Most Procedures Were Of Moderate Length. Abdominal Surgeries Formed The Largest Group (31.3%), Followed Closely By Orthopaedic (28.3%) And Gynaecological Procedures (22.1%), Showing A Balanced Mix Of Surgical Specialties. The Mean Total Opioid Dose Was 11 Mg Morphine Equivalent, Suggesting Standard Analgesic Requirements For Routine

Surgeries. Rocuronium Was The More Commonly Used Neuromuscular Blocking Agent (56.7%), While Vecuronium Was Administered In 43.3% Of Patients. Importantly, 23.3% Of Patients Experienced Intraoperative Hypothermia (<36°C), A Known Contributor To Delayed Emergence Due To Slowed Drug Metabolism And Impaired Neuromuscular Recovery.

Table 2: Intraoperative Anaesthetic And Surgical Variables

Variable	Value
Duration Of Surgery (Minutes)	96.2 ± 29.1
Type Of Surgery	
• Abdominal	75 (31.3%)
• Orthopaedic	68 (28.3%)
• Gynaecological	53 (22.1%)
• Ent	44 (18.3%)
Total Opioid Dose (Morphine Equivalent Mg)	11.0 ± 3.2
Neuromuscular Blocking Agent Used	
• Rocuronium	136 (56.7%)
• Vecuronium	104 (43.3%)
Hypothermia (<36°C)	56 (23.3%)

Table 3 Compares Patient And Intraoperative Characteristics Between Those Who Experienced Delayed Recovery (N = 45) And Those With Normal Recovery (N = 195). Several Variables Showed A Significant Association With Delayed Emergence. Advanced Age Was An Important Factor: 44.4% Of Patients With Delayed Recovery Were Older Than 60 Years, Compared With Only 12.8% In The Normal Recovery Group (P < 0.001). Longer Surgical Duration Also Played A Significant Role. Over Half Of The Delayed Recovery Patients (53.3%) Had Procedures Lasting More Than Two Hours, Compared With 19.5% Of The Normal Recovery Group (P < 0.001). Higher Opioid Exposure (>12 Mg Morphine Equivalent) Was Significantly More Common In The Delayed Recovery Group (40.0% Vs 15.4%, P = 0.001), Suggesting A Dose-Related Sedative Effect. The Strongest Association Was With Residual Neuromuscular Blockade, Present In 64.4% Of Delayed Recovery Patients Versus Only 20.5% Of Those With Normal Recovery (P < 0.001), Highlighting Its Significant Impact On Delayed Emergence. Finally, Intraoperative Hypothermia Was Also More Frequent In The Delayed Recovery Group (44.4% Vs 18.5%, P = 0.002), Underscoring The Role Of Temperature-Related Slowing Of Drug Metabolism. Overall, Table 3 Shows That Delayed Recovery Is Strongly Linked To Older Age, Prolonged Surgeries, Higher Opioid Doses, Residual Neuromuscular Block, And Hypothermia—Factors That Together Point Toward Both Pharmacological And Physiological Contributors To Prolonged Emergence. Gender, Bmi, Diabetes, Hypertension, Intraoperative Blood Loss, And The Choice Of Volatile Anaesthetic Agent (Isoflurane Vs. Sevoflurane) Did Not Show Any Significant Association With The Time To Recovery From Anaesthesia.

Table 3: Incidence And Factors Associated With Delayed Recovery (N = 240)

Parameter	Delayed Recovery (N=45)	Normal Recovery (N=195)	P-Value
Age > 60 Years	20 (44.4%)	25 (12.8%)	<0.001
Female Sex	28 (62.2%)	110 (56.4%)	0.49
Bmi > 30 Kg/M ²	6 (13.3%)	18 (9.2%)	0.42
Diabetes Mellitus	12 (26.7%)	40 (20.5%)	0.36
Hypertension	15 (33.3%)	53 (27.2%)	0.42
Surgery Duration > 2 Hours	24 (53.3%)	38 (19.5%)	<0.001
High Opioid Dose (>12 Mg Me)	18 (40.0%)	30 (15.4%)	0.001
Residual Neuromuscular Block	29 (64.4%)	40 (20.5%)	<0.001
Hypothermia	20 (44.4%)	36 (18.5%)	0.002
Blood Loss > 500 Ml	5 (11.1%)	12 (6.2%)	0.27
Use Of Volatile Agent (Isoflurane Vs Sevoflurane)	8 (17.8%)	26 (13.3%)	0.44

Table 4 Summarises The Multivariate Logistic Regression Analysis Performed To Identify Independent Predictors Of Delayed Recovery From Anaesthesia. After Adjusting For Potential Confounding Variables, Five Factors Remained Significantly Associated With Prolonged Emergence. Advanced Age (>60 Years) Increased The Likelihood Of Delayed Recovery By Nearly Threefold (Aor 2.9), Indicating Reduced Physiological Reserve And Altered Drug Metabolism In Older Individuals. Surgical Duration Beyond Two Hours Was Another Strong Predictor (Aor 3.7), Reflecting The Cumulative Effects Of Prolonged Anaesthetic Exposure And Intraoperative Stress. Higher Intraoperative Opioid Administration Was Independently Associated With Delayed Recovery (Aor 2.3), Consistent With The Sedative And Respiratory-Depressant Properties Of Opioids. Residual Neuromuscular Blockade Emerged As The Most Influential Factor, Increasing The Risk More Than Fivefold (Aor 5.4), Underscoring The Importance Of Adequate Neuromuscular Monitoring And Complete Reversal Before Extubation. Perioperative Hypothermia (<36°C) Also Showed A Significant Association (Aor 2.5), Likely Due To Impaired Drug Clearance And Reduced Neuromuscular Function At Lower Temperatures. Overall, These Results Highlight That Both Patient-Related And Intraoperative Factors Contribute Meaningfully To Delayed Recovery, With Residual Neuromuscular Blockade And Longer Surgeries Being The Strongest Predictors In This Cohort.

Table 4: Multivariate Logistic Regression Analysis Of Factors Associated With Delayed Recovery

Predictor	Adjusted Odds Ratio (Aor)	95% Ci	P-Value
Age > 60 Years	2.9	1.6 – 5.0	0.001
Surgery Duration > 2 Hours	3.7	2.1 – 6.4	<0.001
High Opioid Dose	2.3	1.2 – 4.1	0.01
Residual Neuromuscular Block	5.4	3.0 – 9.5	<0.001
Hypothermia	2.5	1.3 – 4.4	0.006

Discussion:

Delayed Recovery From Anaesthesia Remains A Relevant Perioperative Concern Despite The Widespread Use Of Short-Acting Anaesthetic Agents. In This Study, The Overall Incidence Of Delayed Recovery Was 18.8%, Which Is Comparable To Earlier Observational Reports Showing Rates Between 15–30% In Routine Surgical Populations.⁹ Our Findings Reaffirm That Delayed Emergence Is Usually The Result Of Multiple Interacting Factors Rather Than A Single Cause. Age Emerged As A Significant Determinant, With Patients Above 60 Years Showing Nearly A Threefold Increase In Risk. This Aligns With Observations By Nishikawa Et Al., Who Noted That Ageing Alters Anaesthetic Pharmacokinetics And Increases Sensitivity To Sedatives And Opioids.¹⁰ Similarly, Prolonged Surgical Duration Was Strongly Associated With Delayed Recovery. Longer Procedures May Lead To Greater Tissue Uptake Of Volatile Agents, Temperature Fluctuations, And Cumulative Drug Exposure, Findings Consistent With Previous Studies On Prolonged Anaesthesia.¹¹

Opioid Dose Also Showed An Independent Association In Our Cohort. Excessive Opioid Administration Has Long Been Recognised As A Contributor To Delayed Awakening Due To Persistent Respiratory Depression And Sedation.¹² Although Modern Opioids Provide Predictable Pharmacokinetics, Individual Variability, Surgical Stimulus, And Intraoperative Analgesic Strategies Still Influence Cumulative Dosing. Our Results Echo The Work Of Oderda Et Al., Who Emphasised The Impact Of Higher Opioid Burden On Pacu Stay.¹³

Residual Neuromuscular Blockade Was The Most Powerful Predictor In The Present Study. Even Minimal Degrees Of Incomplete Reversal Can Impair Ventilation, Upper Airway Reflexes, And

Overall Recovery.¹⁴ These Findings Reinforce Earlier Reports Highlighting That Clinical Assessment Alone May Be Inadequate And That Quantitative Neuromuscular Monitoring Significantly Reduces The Incidence Of Postoperative Weakness.¹⁵ Despite Improved Availability Of Reversal Agents, Including Sugammadex, Unrecognised Residual Block Continues To Be Reported In Routine Practice.¹⁶

Intraoperative Hypothermia Also Demonstrated A Significant Association With Delayed Recovery. Hypothermia Slows Drug Metabolism, Prolongs Neuromuscular Blockade, And Reduces Mac Requirements, Ultimately Delaying Emergence.¹⁷ Maintaining Normothermia Has Been Repeatedly Recommended As A Key Element Of Enhanced Recovery Pathways.¹⁸ Our Findings Further Support The Need For Proactive Thermal Management Throughout The Perioperative Period.

Other Commonly Considered Variables—including Gender, Bmi, Diabetes, Hypertension, Intraoperative Blood Loss, And The Choice Of Volatile Anaesthetic Agent—Did Not Show Significant Associations In Our Study. This Is In Agreement With Previous Literature Suggesting That These Factors May Influence Intraoperative Stability But Do Not Independently Prolong Emergence When Modern Balanced Anaesthetic Techniques Are Used.^{19,20}

The Strengths Of This Study Include Its Prospective Design, Uniform Anaesthetic Protocol, And Strict Definition Of Delayed Recovery Using Objective Pacu Scoring. However, Certain Limitations Must Be Acknowledged. The Study Was Conducted In A Single Centre, Which May Limit Generalisability. Depth Of Anaesthesia Monitoring Was Not Routinely Employed, And Therefore Unrecognised Intraoperative Overdosing Cannot Be Entirely Excluded. Additionally, We Did Not Evaluate Postoperative Cognitive Dysfunction, Which May Coexist With Delayed Emergence, Especially In Elderly Patients.^{21,22}

Despite These Limitations, The Study Provides Clinically Relevant Insights. The Findings Emphasise The Need For Meticulous Neuromuscular Monitoring, Judicious Opioid Use, And Maintenance Of Normothermia. Individualised Anaesthetic Planning For Older Adults And Patients Undergoing Prolonged Procedures May Further Reduce The Risk Of Delayed Emergence. Future Studies Incorporating Larger Multicentric Samples And Depth-Of-Anaesthesia Monitoring Devices May Help Refine Risk Prediction Models For Delayed Recovery.^{23,24}

Conclusion:

This Study Involving 240 Patients Identified Key Factors That Independently Contribute To Delayed Recovery From Anaesthesia. Age Above 60 Years, Prolonged Surgical Duration, And Higher Intraoperative Opioid Use Were Strong Predictors, Even After Adjusting For Other Clinical Variables. These Findings Emphasise That Delayed Recovery Is Largely Multifactorial, With Both Patient Characteristics And Perioperative Practices Playing Significant Roles. Elderly Individuals May Have Reduced Physiological Reserves And Altered Drug Metabolism, While Longer Surgeries And Higher Opioid Doses Can Prolong Sedation And Impair Early Postoperative Responsiveness. Recognising These Determinants Allows Clinicians To Anticipate Recovery Challenges And Modify Anaesthetic Plans Accordingly. Strategies Such As Optimising Drug Selection, Minimising Unnecessary Opioid Use, And Implementing Enhanced Recovery Protocols May Help Reduce Delays. Focused Monitoring Of High-Risk Patients Can Further Improve Safety And Postoperative Outcomes. Overall, This Study Reinforces The Need For Individualised Anaesthesia Care To Achieve Timely And Smooth Recovery In Diverse Surgical Populations.

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Conflicts Of Interest: None

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