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Incidence of prolonged time to tracheal extubation and its associated factors among adult patients undergoing elective surgery at Jimma Medical Center, Jimma, Oromia, Ethiopia, 2024

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Abstract

Purpose Extubation refers to removing the breathing tube from the patient's airway after surgery under general anesthesia with tracheal intubation. Extubation procedures typically take less than 15 min, and if they take more, they are prolonged. Whether or not to extubate a patient depends on several factors, including the patient's preoperative status, the type of surgery, anesthetic methods, and expected recovery after the procedure. Thus, the study's objective was to determine the incidence of prolonged extubation and its associated factors among adult patients undergoing surgery at Jimma Medical Center.

Methods A prospective observational study through a consecutive sampling technique was conducted. Ethical clearance and approval were obtained from the institutional review board of Jimma University. Data on the extubation time and possible associated factors for a prolonged extubation time were collected using a data collection checklist. After being entered into EpiData 4.6 and exported into SPSS 25, descriptive analyses and logistic regression were carried out. In multivariate variables, $p \leq 0.05$ was declared as statistical significance.

Result Three-hundred eight adult patients were enrolled in the current study. Of these, the incidence of prolonged extubation was 24.7% (95% *CI* [20.0–29.9]). The identified associated factors were age ≥ 55 years (*AOR* = 5.7, 95% *CI* [2.62, 12.69], $p \leq 001$); ASAPS > II (AOR = 4.27, 95% *CI* [1.59, 11.45], $p = 004$); BMI ≥ 30 kg/m^2 (*AOR* = 6.6, 95% *CI* [2.37, 18.36], $p \leq 001$); the use of benzodiazepine (*AOR* = 3.43, 95% *CI* [1.42, 8.25], $p = 0.006$); using of isoflurane (*AOR* = 0.35, 95% *CI* [0.15, 0.78], $p = 0.011$); prone position (*AOR* = 4.68, 95% *CI* [1.56, 14.07], $p = 0.006$); extubation in afternoon (*AOR* = 2.69, 95% *CI* [1.26, 5.74]; $p = 0.011$); and duration of surgery ≥ 210 min (*AOR* = 5.2, 95% *CI* [2.32, 11.72], $p \leq 0.001$).

Conclusions The study found that prolonged time to extubation occurred in one-fourth of the patients. The independent factors statistically associated with prolonged extubation were older ages, higher ASA class, obesity (≥ 30 kg/m^2), the use of benzodiazepine, halothane for maintenance, prone position, extubation in the afternoon, and longer procedures (≥ 210 min).

Keywords Incidence, Prolonged extubation, General anesthesia

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Introduction

Endotracheal intubation is the standard technique for securing airway during general anesthesia (Afolayan and Ademuyiwa 2010, Agoliati et al. 2010). Removing an endotracheal tube, which liberates a patient from the anesthesia machine, is normally done after the procedure once the patients have regained consciousness and can breathe on their effort (Arora et al. 2022, Artime and Hagberg 2014). Thus, ventilator status should be assessed, and standard criteria for extubation should be met. When the airway is severely compromised, delaying extubation may be safer (Bagilkar et al. 2020). Following general anesthesia (GA), the time to tracheal extubation is measured from the end of surgery (EOS) to the removal of the endotracheal tube, which takes less than 15 min (Bayman et al. 2016, Benham-Hermetz and Mitchell 2021). The occurrence of greater or equal to the 15-min interval between the EOS and the extubation is known as the prolonged time to tracheal extubation (Chan et al. 2016, Dexter and Epstein 2013). Indeed, extubation time (ET) is one element of the nonoperative time of operation room (OR) for surgical cases done under general anesthesia (Kaddoum et al. 2022, Dexter et al. 2013).

Previous studies report that the incidence of prolonged extubation is widely varying and relatively high even in developed, 10–20.3%, routine practice (Cook 2011, Dexter et al. 2010, Divatia and Bhowmick 2005, Epstein et al. 2020). Among the factors that must be considered are the patient's preoperative condition, the patient's intraoperative course (procedure length, type, and location), the patient's underlying medical conditions (such as lung or heart disease), and the patient's current clinical status, i.e., fluid balance, hemodynamic stability, level of consciousness, muscle strength, and temperature (Epstein et al. 2013, House et al. 2016). In addition, anesthetic drug usage, inappropriate management or practice during anesthesia (Kaddoum et al. 2022, Kanaya et al. 2017), and anticipated postoperative recovery when deciding whether to extubate the patient are risk factors for a prolonged time to extubation (Kobayashi et al. 2020, Lai et al. 2017). Extubation time is particularly important because it can be modified by a variety of anesthetic drugs or procedures, as well as a variety of patient and surgical-related factors (Cook 2011, Epstein et al. 2020, Lai et al. 2019).

Prolonged extubation can have several negative consequences (Cook 2011), including an increased risk of respiratory complications. Patients with prolonged extubation time are more likely to experience pneumonia, atelectasis, an increased risk of reintubation, an increased need for further respiratory interventions, and respiratory failure (Gropper 2019). The breathing tube can be uncomfortable and even painful for some patients. It might also cause inefficient use of personnel, increased patient waiting times and costs, decreased anesthesia care efficiency, inefficient operating room workflow, and a role as a system bottleneck for patient flow through OR (Lai et al. 2020, Masursky et al. 2012). Compared to regular extubations, there was a greater chance that OR team members would wait idle during delayed extubations, which would impede workflow (Benham-Hermetz and Mitchell 2021, Chan et al. 2016, Dexter and Ledolter 2023). Prolonged extubation can cause a delay in discharge from the OR and then from the hospital, leading to increased costs and inconvenience for patients. Thus, considering the expense of OR, determining the variables that contribute to a prolonged extubation time may help to increase OR and anesthesia care efficiency (Benham-Hermetz and Mitchell 2021, Masursky et al. 2012). Moreover, awareness of the variables associated with PET will allow healthcare providers to minimize combinations of risk factors, reduce the frequency and extent of PET, and improve a patient's anesthesia experience (Misal et al. 2016).

Most of the prior studies were conducted in developed countries with advanced intraoperative monitoring and were primarily concerned with the managerial consequences of prolonged extubation. The risk factors that have been identified in developed countries may not be the same as those in developing countries due to differences in the healthcare system, patient population, and surgical practices (Bayman et al. 2016). For instance, neuromuscular monitoring equipment, depth of anesthesia monitors, and reversal agents like sugammadex, which can reverse the effect of NMB even at a deep level of relaxation, were not available in the study setup. Thus, the clinician must rely on clinical assessment (Kaddoum et al. 2022, Pandit 2011) to monitor the condition of the patients, and the study aims to find out how often prolonged extubation time occurs in these settings. Moreover, despite the importance of extubation time in anesthesia care efficiency and its impact on OR management and patient outcome, there is no clear data regarding the incidence of prolonged extubations and its associated risk factors in sub-Saharan countries, particularly in Ethiopia. The primary aim of this study is to determine the incidence of prolonged time to extubation, and the secondary aim is to identify the independent factors associated with prolonged time to extubation among adult patients undergoing elective surgery under general anesthesia.

Methods and materials

Study setting

The study was carried out from November 10, 2023, to January 25, 2024 (data collection) at the Jimma Medical Center (JMC). Jimma University Medical Center (JMC) is one of the oldest public hospitals in the country with a bed capacity of 800. Geographically, it is located in the city of Jimma, 352 km southwest of Addis Ababa. Currently, it is the only teaching and referral hospital in the southwestern part of the country, providing services for approximately 16,000 inpatients, 220,000 outpatient attendants, 12,000 emergency cases, and 4500 deliveries in a year coming to the hospital from the catchment population of about 15 million people. JMC has nine major operation rooms including ophthalmic procedures and two additional operation rooms for cesarean sections. Elective surgery done at JUMC is multidiscipline (specialty and subspecialty), i.e., pediatric, EENT, and maxillofacial, neurosurgery, orthopedics, obstetrics and gynecology, ophthalmic surgery, general surgery, GIT and hepatobiliary surgeries and urology, thoracic surgery, plastic surgery, and reconstruction. General anesthesia is one of the most common types of anesthesia given at the setup, and the regional anesthesia technique was less than 10% of the procedures. At JMC, there were various anesthesia specialists: nonphysician anesthetists (MSc (21) or BSc (9) degrees in anesthesia), physician anesthetists (8) (MD specializing in anesthesiology), and anesthesiology residents who perform under the anesthesiologist's supervision.

Study design

An institutional-based prospective observational study was done at Jimma Medical Center from November 10, 2023, to January 25, 2024.

Population

The source populations were all adult patients who underwent surgery at Jimma Medical Center. The study population was adult patients who underwent elective surgery under general anesthesia with an endotracheal tube during the study period at JMC and were included in the study.

Sample size and sampling technique

The current hospital logbook shows that on average, there were ≈7 elective adult patients operated under general anesthesia on a day at JMC for the past 3 months. This means ≈455 adult patients were done in the past 3 months, and we planned to include all eligible patients for 2 months and 2 weeks. By considering the financial constraints and the total number of adult patients operated under general anesthesia for the past three months, we planned two months and two weeks for data collection consecutively. A total of 308 eligible patients were operated on during the study period of 2 months and 2 weeks, and all of them were included in the study. All consecutive eligible adult patients undergoing elective surgery under GATE were recruited and included from November 10, 2023, to January 25, 2024, GC.

Eligibility criteria

All adult patients (≥ 18 years) undergoing elective surgery under general anesthesia with an endotracheal tube (GATE) at JMC were included in the study. The exclusion criteria included patients who came to the OR with a tracheal airway already in place, those discharged from the OR without undergoing extubation, and patients with ASAPS > 3.

Data collection procedures

A data collection checklist was developed in reference to pre-anesthesia evaluation sheets, intraoperative monitoring sheets, surgical logbooks, and other standardized tools from similar studies. Two anesthetists and two diploma nurse anesthesia assistants were collecting the data. Data were gathered through an observational data checklist on the incidence and potential risk factors for prolonged extubation time, including patient demographics, ASA class, preoperative comorbidity, types/sites of surgery, types of anesthesia maintenance, administered anesthesia drugs and ventilation modalities, position during surgery, duration of surgery, starting time of surgery, time of skin closure, attending anesthesia provider, time of tracheal removal, and duration of anesthesia, anesthetic start, and end times. Extubation time is measured as the duration between the end of the operation and tracheal tube removal, and PET was considered if it lasted for more than or equal to 15 min.

Study variables

Dependent variable

➢ Prolonged time to extubation(yes/no)

Independent variable

➢ Age, BMI, and sex
➢ Preoperative hemoglobin
➢ Mallampati class
➢ ASA's physical status
➢ Preexisting comorbidities
➢ Attending anesthesia providers
➢ Induction agent used

- ➢ Maintenance agents used
- ➢ Lung protective ventilation used
- ➢ Duration of anesthesia
- ➢ Opioids, BDZ, and vasoactive used
- ➢ Muscle relaxant agents used
- ➢ Reversal agent used mg/kg
- ➢ Hour of extubation/morning or afternoon
- ➢ Type/site of surgery
- ➢ Position during surgery
- ➢ Duration of surgery
- ➢ Intraoperative blood loss
- ➢ Blood transfusion
- ➢ Total amount of fluid given (ml/kg/h)
- ➢ Body temperature (°C) at EOS
- ➢ MAP at EOS (mmHg)
- ➢ ETCO2 at the EoS (mmHg)

Operational definition

- ➢ *Extubation:* Removing an endotracheal tube
- ➢ *Anesthesia-controlled time*: It includes anesthesia waiting time, induction time, intubation, recovery, and extubation time.
- ➢ *Duration of anesthesia*: The time starts from the induction of anesthesia drugs to the discontinuation/end of administering anesthesia.
- ➢ *End of surgery*: The skin incision was closed and dressed.
- ➢ *Extubation time*: The time duration from the end of surgery to the endotracheal tube removal
- ➢ *Hour of extubation*: An hour at which the patient is extubated, we define it as morning (08:00 am–01:00 pm) and afternoon (01:00 pm to 07:00 pm).
- ➢ *Prolonged time to extubation*: The time between the end of surgery to tracheal tube removal ≥ 15 min.

Data analysis

All the data collected were arranged, categorized, checked, coded, and entered into EpiData version 4.6, and SPSS version 25 was used to analyze the data. Descriptive analyses were conducted for sociodemographic factors and perioperative patients' conditions, and the results were presented in texts, tables, and graphs using summary measures such as frequencies, percentages, mean, and standard deviation as appropriate. The Pearson's chi-squared test was performed to determine the degree of significance, and a *p*-value less than or equal to 0.05 with a 95% confidence interval was regarded to be a statistically significant difference. Cases with prolonged extubation time were compared against the cases without prolonged extubation. The incidence of prolonged extubation time was estimated with a 95% confidence interval. Bivariate binomial logistic regression was done to evaluate the relationship between a single independent and dependent variable. All variables with a *p*-value ≤ 0.25 were entered into multivariable regression to control for all possible confounders, and the variables were selected by the backward stepwise method to see the effect of each variable on the outcome variables. Finally, the findings of the multivariable logistic regression analysis were presented using the adjusted odds ratio along with their 95% confidence interval. The level of statistical significance was declared at a *p*-value ≤ 0.05.

Data quality management

To ensure data quality, 1 day of training was given to data collectors with the aim of the study and the content of the data abstraction format. One week before actual data collection started, pre-testing was done at Shenen Gibe Hospital on 10% of the sample size to assess the clarity, sequence, validity, consistency, and understandability of the data collection tools, and a few modifications were made. The suitability and validity of the data collection format were also assessed through discussion with the advisors and anesthesia professionals' experts. The principal investigator and supervisor supervised the data collection process daily to ensure that the data were accurate, consistent, and comprehensive. The missing data for each patient were checked daily by supervisors.

Results

Sociodemographic and clinical characteristics of the patients who underwent surgery under GATE at JMC, Jimma, Ethiopia, 2024

A total of 308 patients were involved in this study. All of the sampled patients responded to the interview for sociodemographic characteristics. The majority of patients, 85.4% (263), were classified as ASA classless or equal to II. Of all the study subjects, 47.4% were males (Table 1). The average mean age of the participants was 42.9 ± 16.6 years (with a minimum of 18 years and a max of 70 years), and 29% of patients were greater or equal to 55 years old (Table 1). Among the sampled patients, 87.1% (268) of them had preoperative *Hgb*≥ 10 mg/dl. The patients were interviewed for the preoperative status of comorbidities, and Tables 1 and 2 highlight that three-fourths of the patients had no known comorbidity, and 13% (38), 5.2% (16), and 4.5% (14) of the clients had respiratory, cardiovascular, renal, and/or endocrine system, respectively.

Table 1 Baseline distribution of sociodemographic and clinical characteristics of the patients who underwent elective surgery under GATE at JMC, Jimma, Ethiopia, 2024

Variables	Categories	Frequency (%)
Sex	Male	146 (47.4%)
	Female	162 (52.6%)
	Total	308 (100%)
Age	< 55 years	219 (71.1%)
	≥ 55 years	89 (28.9%)
BMI	< 30 kg/m^2	269 (87.4%)
	≥ 30 kg/m^2	39 (12.6%)
Preoperative hemoglobin	< 10 mg/dl	39 (12.7%)
	≥ 10 mg/dl	269 (87.3%)
ASAPS	ASA I or II	263 (85.4%)
	ASA III	45 (14.6%)
	Total	308 (100%)
Mallampati class	I or II	264 (85.7%)
	III or IV	44 (14.3)
	Total	308 (100%)
Preop comorbidity	No known comorbidity	233 (75.6%)
	Respiratory disease	40 (13%)
	Cardiac disease	16 (5.2%)
	Renal and/or endocrine disease	15 (4.8%)
	Neurologic disease	7 (2.3%)

Table 2 Descriptive data on the distribution of sociodemographic and clinical characteristics with extubation time status of the patients who undergone elective surgery under GATE at JMC (N = 308)

Variables	Categories	Extubation time status	
		Regular ET	PET
Sex	Male	115 (37.3%)	31 (10.0%)
	Female	117 (38.0%)	45 (14.7%)
Age	< 55 years	183 (59.4%)	36 (11.7%)
	≥ 55 years	49 (15.9%)	40 (13.0%)
BMI	< 30 kg/m^2	218 (70.8%)	51 (16.6%)
	≥ 30 kg/m^2	14 (4.5%)	25 (8.1%)
Preop hemoglobin	< 10 mg/dl	32 (10.4%)	7 (2.3%)
	≥ 10 mg/dl	200 (64.9%)	69 (22.4%)
ASAPS	ASA ≤ II	208 (67.5%)	56 (18.2%)
	ASA III	24 (7.8%)	20 (6.5%)
Mallampati class	I or II	199 (64.6%)	64 (20.8%)
	III or IV	33 (10.7%)	12 (3.9%)
Preop comorbidity	No comorbidity	185 (60.1%)	48 (15.6%)
	Respiratory disease	23 (7.5%)	15 (4.9%)
	CVS	10 (3.2%)	6 (1.9%)
	Renal and/or endocrine	9 (3.9%)	5 (1.6%)
	Neurologic disease	5 (1.6%)	2 (0.6%)

Anesthesia and surgical-related data of the patients who underwent elective surgery under GATE at JMC, Jimma, Ethiopia, 2024

Table 3 shows that 43%, 28%, and 29% of patients were done with a BSc anesthetist, MSc holder anesthetist, and anesthesiologist residents, respectively. Of all the patients, 54.2% (167), 18.2% (56), and 27.6% (85) received ketamine, ketofol, and propofol as induction agents, respectively. Among all, 81.5% (251) of the patients took opioids, and similarly, 17.5% (54) of the patients took benzodiazepine. More than half (57.8%) of the patients were maintained with halothane, and more than three-fourths (76.6%) of the patients) took both suxamethonium and vecuronium, whereas only 6.5% (20) of the patients took suxamethonium alone. The average mean of ETCO2 at the EOS was 37.4 ± 2.9 mmHg among total patients, and similarly, the average mean of body temperature at EOS was 35.9 ± 0.690 °C. During the study period, the most common type of surgery done was general surgery (general surgery out of the abdomen, 12.3% (38), and thorax-abdominal surgery, 24.4%) (75). Most of the procedures were done in the supine position (73.1%, followed by the prone (10.4%), and steeper Trendelenburg (6.5%), as shown in Table 3. Among the study subjects, 39.3% (121) of patients had < 500 ml estimated intraop blood loss, whereas 45.8% (141) and 14.9% (46) of the patients had 500–1000 ml and > 1000 ml of intraoperative estimated blood loss respectively (Table 3).

Incidence of prolonged extubation time among the patients who underwent elective surgery under GATE at JMC, Jimma, Ethiopia, 2024

The cumulative incidence of prolonged extubation time was 24.7%, 95% CI [20.0–29.9] (Fig. 1) and more common among the patients greater or equal to 55 years old (47.1% vs. 16%, $p < 0.001$) (Fig. 2). It was more frequent in respiratory comorbidities like COPD, asthma, lung cancer, and OSA compared to those with no known comorbidity (39.5% vs. 20.6%, $p = 0.032$). The patient with cardiovascular system comorbidity also had a higher incidence of PET than the patient with no known comorbidity (37.5% vs. 20.6%).

There was a significant statistical association between anesthesia providers' experience and the incidence of prolonged extubation time ($p < 0.001$) (Fig. 3). It was more frequent among patients who took BZD (50.9% vs. 19.3%, $p < 0.001$). The patients maintained with halothane had a higher cumulative incidence of PET compared to those who maintained with isoflurane (34.3% vs. 11.5%, $p < 0.001$). The incidence of PET was higher, 40% among patients who took low doses (0.01–0.03 mg/kg) of neostigmine and 23.5% among patients who took normal doses (0.031–0.07 mg/kg) of neostigmine($p = 0.032$).

Table 3 Frequency distribution of anesthesia and surgery-related factors with extubation time status of the patients who undergone elective surgery under GATE at JMC ($N = 308$)

Variables	Categories	Extubation time status	
		Regular ET	**PET**
Induction agents	Ketamine	126 (40.9%)	41 (13.3%)
	Ketofol	41 (13.3%)	15 (4.9%)
	Propofol	65 (21.1%)	20 (6.5%)
Opioid used	No	51 (16.6%)	6 (1.9%)
	Yes	181 (58.8%)	70 (22.7%)
Maintenance agent	Halothane	117 (38.0%)	61 (19.8%)
	Isoflurane	115 (37.3%)	15 (4.9%)
Lung protective	Yes	143 (46.4%)	50 (16.2%
	No	89 (28.9%)	26 (8.4%)
Muscle relaxant	Sux only	18 (5.8%)	2 (0.6%)
	NDMR only	37 (12.0%)	12 (3.9%)
	NDMR ± Sux	177 (57.5%)	62 (20.1%)
Transfusion	Yes	18 (5.8%)	9 (2.9%)
	No	214 (69.5%)	67 (21.8%)
Fluid	Mean ± SD (ml/kg/h)	29.8 ± 9.8	34.7 ± 12.1
Vasoactive used	No	215 (69.8%)	71 (23.1%)
	Yes	17 (5.5%)	5 (1.6%)
Hour of extubation	Morning	154 (50%)	30 (9.7%)
	Afternoon	78 (25.3%)	46 (14.9%)
BDZ used	No	205 (66.6%)	49 (15.9%)
	Yes	27 (8.8%)	27 (8.8%)
Neostigmine (mg/kg)	0	19 (6.2%)	1 (0.3%)
	0.01–0.03	15 (4.9%)	10 (3.2%)
	0.03–0.07	166 (53.9%)	52 (16.9%)
	> 0.071	32 (10.4%)	13 (4.2%)
MAP at EOS	Mean ± SD (mmHg)	93.03 ± 23.6	94.54 ± 20.7
$ETCO_2$ mmHg	Mean ± SD	37.47 ± 3.1	37.13 ± 2.4
Tm at EOS	Mean ± SD (0 °C)	35.9 ± 0.7	35.7 ± 0.5
Blood loss	< 500 ml	100 (32.5%)	21 (6.8)
	500–1000 ml	107 (34.7%)	36 (11.7%)
	> 1000 ml	25 (8.1%)	19 (6.2%)
Position of patients during the procedure	Supine	180 (58.4)	45 (14.6%)
	Prone	16 (5.2%)	16 (5.2%)
	Lateral	23 (7.5%)	8 (2.6%)
	Others	13 (4.2%)	7 (2.3%)
Type of surgery	General surgery/out of abdomen/	31 (10.1%)	7 (2.3%)
	ORMF & ENT	35 (11.4%)	2 (0.6%)
	Urologic surgery	24 (7.8%)	6 (1.9%)
	Orthopedic	22 (7.1%)	6 (1.9%)
	Plastic	25 (8.1%)	8 (2.6%)
	Obstetrics/gynecology	36 (11.7%)	5 (1.6%)
	Ophthalmologic	12 (3.9%)	3 (1.0%)
	Thoraco-abdominal	41 (13.3%)	34 (11.0%)
	Neurosurgery	6 (1.9%)	5 (1.6%)
Duration of surgery	< 210 min	197 (64.0%)	31 (10.1%)
	≥ 210 min	35 (11.4%)	45 (14.6%)

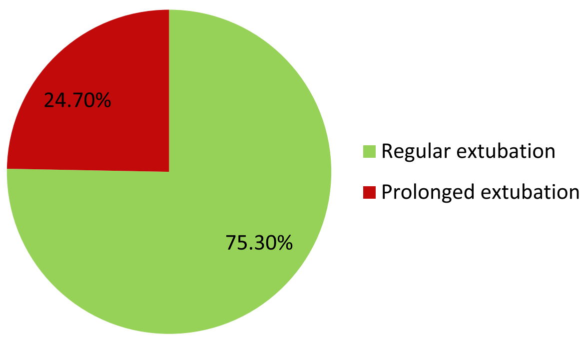

Fig. 1 Incidence of prolonged extubation time among adult patients who undergone elective surgery under GATE at JMC, 2024

The incidence of PET was more frequent among longer procedures (47.8% vs. 22.8%, $p = 0.007$). Both neurosurgery (45.5%, $p < 0.001$) and thoracoabdominal surgery patients showed a considerable incidence of PET (45.3%) (Table 3). The incidence of PET was higher among patients who were extubated afternoon (01:00 pm–7:00 pm) than those extubated morning (8:00 pm–1:00 pm) (37.1% vs. 16.3%) (Fig. 4).

Factors associated with PET among elective adult patients operated under GATE at JMC, Oromia, Ethiopia, 2024

In bivariate analysis age of patients, sex, preexisting comorbidities, ASAPS, BMI, anesthesia providers, use of BDZ, use of opioids, type of maintenance agent used, position during operation, type/site of surgery, type of muscle relaxant used, amount of IV fluid given,

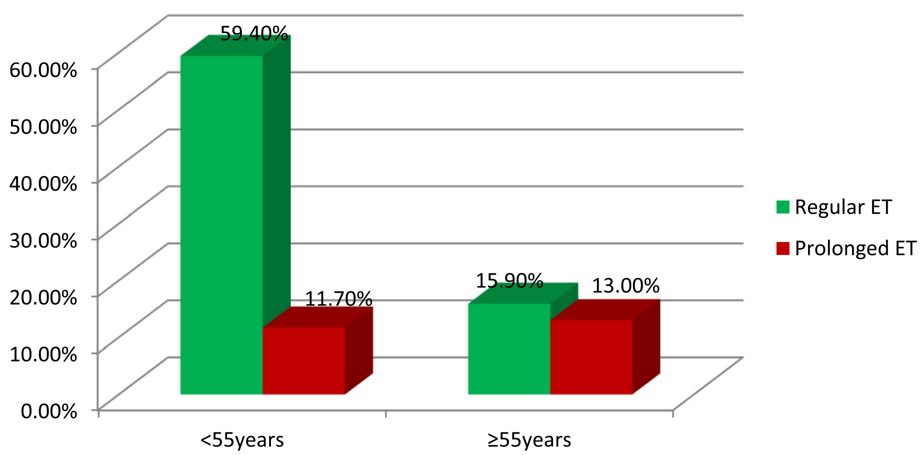

Fig. 2 Extubation time status based on the age of patients among adult patients who undergone elective surgery under GATE at JMC, 2024. *ET, extubation time

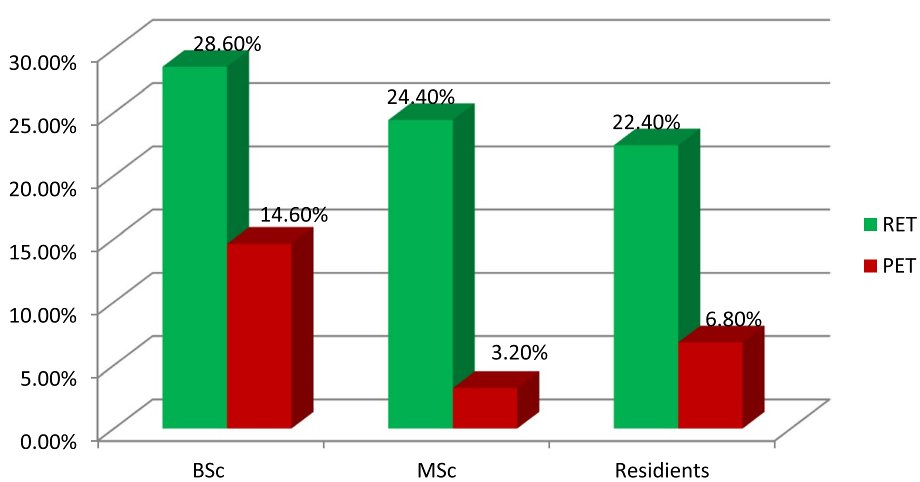

Fig. 3 Extubation time status based on the anesthesia providers among adult patients who undergone elective surgery under GATE at JMC, 2024. *RET, regular extubation time; PET, prolonged extubation time

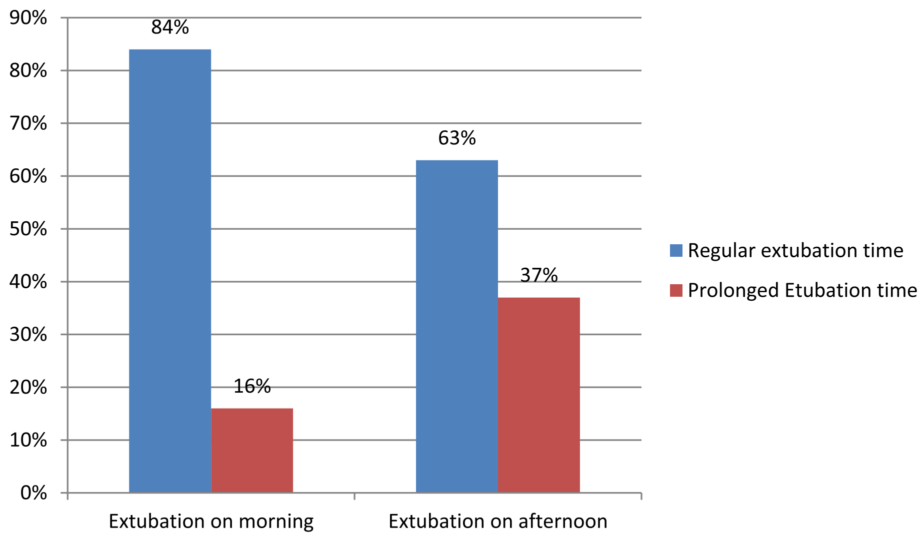

Fig. 4 Extubation time status based on the hour at which patients were extubated among adult patients who undergone elective surgery under GATE at JMC, 2024

Table 4 Bivariate and multivariate logistic regression model to identify factors associated with PET among elective adult patients operated under GATE at JMC (*N* = 308) Jimma, Ethiopia, 2024

Variable	Category	Extubation time status		COR 95% *CI*	AOR, 95% *CI*	*p*-value
		Regular ET	PET			
Age	< 55 years	183 (59.4%)	36 (11.7%)	Ref.	1	
	≥ 55 years	49 (15.9%)	40 (13.0%)	4.15 (24, 7.19)*	5.7 (2.62, 12.69)	< 0.001**
BMI	< 30 kg/m^2	218 (70.8%)	51 (16.6%)	Ref.	1	
	≥ 30 kg/m^2	14 (4.5%)	25 (8.1%)	7.6 (3.71, 15.71)*	6.6 (2.37, 18.36)	< 0.001**
ASAPS	ASA < III	208 (67.5%)	56 (18.2%)	1	1	
	ASA III	24 (7.8%)	20 (6.5%)	3.1 (1.6, 6.01)*	4.27 (1.59, 11.45)	0.004**
M/agent	Halothane	117 (38.0%)	61 (19.8%)	1	1	
	Isoflurane	115 (37.3%)	15 (4.9%)	0.25 (0.13, 0.47)*	0.35 (0.15, 0.78)	0.011**
Anesthesia provider	BSc	88 (28.6%)	45 (14.6%)	1	1	
	MSc	75 (24.4%)	10 (3.2%)	0.26 (0.12, 0.55)*	0.37 (0.15, 0.93)	0.002**
	Resident	69 (22.4%)	21 (6.8%)	0.60 (0.33, 1.09)*	0.25 (0.07, 0.55)	0.035**
DOS	< 210 min	197 (64.0%)	31 (10.1%)	1	1	
	≥ 210 min	35 (11.4%)	45 (14.6%)	8.17 (4.57, 14.6)*	5.2 (2.32, 11.72)	< 0.001**
HOE	Morning	154 (50%)	30 (9.7%)	1	1	
	Afternoon	78 (25.3%)	46 (14.9%)	3.03 (1.77, 5.17)*	2.69 (1.26, 5.74)	0.011**
BDZ used	No	205 (66.6%)	49 (15.9%)	1	1	
	Yes	27 (8.8%)	27 (8.8%)	4.18 (2.27, 7.76)*	3.43 (1.42, 8.25)	0.006**
Position during procedure	Supine	180 (58.4)	45 (14.6%)	1	1	
	Prone	16 (5.2%)	16 (5.2%)	4.00 (1.86, 8.60)*	4.68 (1.56, 4.07)	0.006**

[*] Candidate variables in binary regression at $p \leq 0.25$

**Indicates statistically significant variables in multivariable logistic regression at $p \leq 0.05$

intraoperative estimated blood loss, body temperature at the EOS, hour at which patient was extubated, and duration of operation were candidates for multivariate regression (Table 4). The correlation between those independent variables was checked for multicollinearity effect, by using variance inflation factor (VIF) and tolerance test for those p-values < 0.25. Duration of anesthesia and surgical procedure duration have statistically significant multicollinearity, and duration of anesthesia goes with the duration of procedure. Moreover, in this data, the duration of anesthesia was dependent on the duration of the procedure; so, the duration of surgery was included in the multivariate logistic regression. The results of multivariate logistic regression showed that the age of the patients, BMI, ASAPS, anesthesia providers, inhalational agents used, use of BDZ, position during surgery, an hour at which the patient was extubated, and duration of surgery had a statistically significant association with PET at a p-value ≤ 0.05 (Table 4). Eight of the factors that were statistically significant in bivariate regression, including gender, preoperative comorbidity, intraoperative estimated blood loss, opioid use, amount of IV fluid given, type/site of surgery, type of neuromuscular blockade used, and body temperature at EOS, did not show a statistically significant association with the PET in multivariate logistic regression.

Older than or equal to 55-year-old patients had six times higher likelihood of having prolonged extubation (*AOR* = 5.7, 95% *CI* [2.62, 12.69]). Obese patients (≥ 30 kg/m^2) were more than six times more likely to have PET (*AOR* = 6.6, 95% *CI* [2.37, 18.36]). The odds of having PET were more than four times higher among patients who have ASA physical status III compared to patients with ASAPS ≤II (*AOR* 3.34, 95% *CI* [1.26, 8.80]). Patients treated with higher academic rank anesthesia providers are less likely to develop (*AOR* = 0.37, 95% *CI* [0.15, 0.93], p = 0.035, MSc) and (*AOR* = 0.25, 95% *CI* [0.07, 0.55], p = 0.002, anesthesiologist resident (2 and 3). The odds of having PET were 3.4 times higher in those who took BDZ compared to those who did not (*AOR* 3.42 [1.42, 8.25]). Similarly, the odds of having PET were 0.35 times lower among patients maintained with the isoflurane group when compared to those maintained with halothane (*AOR* = 0.35, 95% *CI* [0.15, 0.78]). Patients who underwent procedures lasting more than 2 and half hours had a five times higher probability of developing PET (*AOR* = 5.2, 95% *CI* [2.32, 11.72]), and patients who were operated in the prone position had a 4.6 times higher probability of developing PET than those operated in the supine position (*AOR* = 4.68, 95% *CI* [1.56, 4.07]). The odds of having PET were nearly threefold higher among patients who were extubated in the afternoon compared to those who were extubated in the morning (*AOR* 2.67, 95% *CI* [1.56, 5.74]) (Table 4).

Discussion

The primary finding of this study was the 24.7% with 95% *CI*[20.0–29.9] incidence of prolonged tracheal extubation time. This figure compares with 20.31% of reported in a study done in 2016 in IOWA, USA; even though the study was focused on anesthesiologist performance, not all patients were included (Misal et al. 2016). The previous studies report the incidence of prolonged extubation to be around 10–15% in routine practice in the developed region which is less than the current result (Benham-Hermetz and Mitchell 2021, Cook 2011). The discrepancy may be due to differences in the advancement of technology in anesthesia care and monitoring equipment.

Our study figure contrasts with the 9.6% reported in a Nigerian teaching hospital study (Shimamoto et al. 2022). We hypothesize that the primary reason for the discrepancy may be that the extubation time was considered prolonged if the duration between the end of surgery and extubation was more than or equal to 30 min in the Nigerian study, while it was more than or equal to 15 min in the current investigation. The incidence of prolonged extubation was more frequent when compared with a study conducted in Taiwan among open colorectal surgery, which found that 14.2% and 9.7% of patients had PET among the DES and TIV groups, respectively (Lai et al. 2019). Similarly, the study done on laparoscopic cholecystectomy revealed 4.5% vs. 10.1% in the TIVA group and the DES group, respectively (Sugiyama et al. 2021), and 9.8% among the DES group in open colorectal surgery patients (Tikka and Hilmi 2019). We believe this discrepancy could be attributed to the fact that in the current study, several types and sites of surgeries were included, and variations in anesthetic care can facilitate significant differences in patient recovery immediately after anesthesia.

The present results reveal that prolonged extubation was higher than reported in a recent study done in Japan's hospitals (6%) (Dexter et al. 2010). This discrepancy may be due to differences in the advancement of technology in caring and monitoring equipment. The availability of newly invented inhalation for maintenance like desflurane, sevoflurane, and neuromuscular blocked level monitoring varies among countries. Our current finding, greater than (24.7%), a historical cohort study, done in 2016, in Boston reported that the incidence of prolonged extubation time was 13.9% (Vannucci et al. 2021). A recent single-center retrospective study observed at IOWA University (USA) shows that 10% of the patients develop PET which is significantly lower than our current finding, and prolonged extubation increases the escalation of care in PACU. The discrepancy may be due mainly to the inclusion of cardiothoracic, ENT, and neurosurgery cases in the current study (Gropper 2019). Our study's incidence of prolonged extubation (24.7%) was higher than the prior study's overall incidence of prolonged extubation (15% of all patients in developed countries) (Benham-Hermetz and Mitchell 2021, Chan et al.

2016). The difference might result from using different IAA for maintenance; desflurane's poor blood/gas partition coefficients speed up its body's excretion. Perhaps it is also due to differences in OR setup and anesthetic monitoring equipment settings.

Furthermore, the current study discovered that significant association between several factors and prolonged tracheal extubation. The study shows that patients older or equal to 55 years old were 5.7 times more likely to develop PET. This result was consistent with earlier research conducted in the USA, Japan, and Nigeria (House et al. 2016, Shimamoto et al. 2022, Sugiyama et al. 2021). Reduced physiological reserve, impaired clearance of anesthetic drugs, and delayed responses to stimuli could make it more difficult for older adults to recover from the effects of anesthesia and muscle relaxants. Similar to Bayman et al. (2016), who found a slight but discernible influence of the anesthesia provider on the likelihood of a prolonged time to tracheal extubation, the current finding shows that the odds favoring a prolonged extubation time vary among anesthesia providers (Misal et al. 2016). Prolonged periods of tracheal extubation time have been associated with a lack of experience of the anesthetic provider in a previous study (Kaddoum et al. 2022).

Our current study found that patients maintained with isoflurane were less likely to develop PET than patients maintained with halothane (Bayman et al. 2016). Desflurane/isoflurane poor blood/gas partition coefficients speed up its body's excretion more than halothane. Patients who were extubated in the afternoon had the odds of having a PET than patients who were extubated in the morning, according to our study, which looked at the time to extubation comparing patients who were extubated in the morning and afternoon. This could be related to the anesthesia provider's fatigue and prolonged NPO time, and those extubated afternoons endured a longer procedure that began in the morning and ended in the afternoon. Epstein et al. (2013) reported that (Divatia and Bhowmick 2005) at least 55.6% of protracted extubation times occurred with cases on regular workdays and in an OR with more than 8 h of cases and turnover.

In line with our study (Lai et al. 2019), a study carried out in Taiwan found that surgical times longer than 210 min strongly affect PET. During longer surgical procedures, higher than necessary anesthetic levels may accumulate and be redistributed from adipose tissue and muscle to the plasma, which leads to delayed awakening from anesthesia (Arora et al. 2022, Vitez and Macario 1998). As a result, maintaining anesthetic depth within the prescribed range may optimize anesthetic delivery and postoperative recovery after somewhat deep anesthesia, and the use of the bispectral index (BIS) is strongly suggested in patients who are older or have had a longer surgery time Dexter and Ledolter 2023.

The study shows that BZD usage influences the time of awakening from anesthesia and prolonged extubation time, which is consistent with previous findings (Kobayashi et al. 2020). Medication belonging to the benzodiazepine class can affect prolonged extubation time due to its sedative and muscle relaxant properties. Moreover, we confirmed previously identified associated factors ASAPS > II. A previous study found that ASAPS > II was more likely to experience prolonged extubation time (Vannucci et al. 2021). A prior study found that comorbidities had no association with delayed extubation, which is consistent with our current finding (House et al. 2016). Prolonged time to tracheal extubations was significantly and substantially linked to longer patient transfer from the OR, and when it occurs, members of the OR team are idle waiting for extubation (i.e., prolonged time to tracheal extubations are bottlenecks to patient flow (Dexter and Epstein 2013, Masursky et al. 2012). The present finding shows the average mean time between EOS to patient transfer from OR was prolonged, which is 27.3 ± 6.9 min in one-fourth of the cases which was in line with the prior study (Wong et al. 2021).

Strengths and limitations of the study

One of the study's strengths was its exhaustive collection of data prospectively for 2 months and 2 weeks.

There are certain limitations to our study as well. Firstly, we did not follow up with these patients who had developed PET over an extended period to identify any further problems or to ascertain the patient's fate. In addition, this was a single-center study with a small sample size that included only adult patients who had undergone elective surgery and emergency procedures, which might have experienced a greater incidence of PET, influencing the findings of this investigation.

Conclusion

The study found that prolonged time to tracheal extubation occurred in one-fourth of cases at JMC, which was clinically relevant. Moreover, many independent factors significantly determine the incidence of prolonged extubation time identified, i.e., the age greater or equal to 55, ASA class III or higher, higher BMI (≥ 30 kg/m^2), use of benzodiazepines, inexperienced anesthesia providers, the use of halothane for maintenance, prone position during surgery, anesthesia ending time (extubation) after 1:00 pm (afternoon), and longer procedures(> 210 min).

Recommendation

Based on the findings of this study, departments of anesthesiology and critical care should provide further training and education to anesthesia providers to reduce the incidence of prolonged extubation. Staffing and training of anesthetists need to be supported, depending on the factors influencing extubation time, with ongoing education and quality assurance developed to address the factors affecting extubation time.

The incidence of PET in JMC is higher than in previous studies conducted in other countries; thus, it could potentially be required to utilize the standard ASA guidelines in the OR and to reduce and intervene the time to extubation. An anesthesia provider should consciously identify and monitor those patients at risk for a prolonged time to tracheal extubation to prevent and decrease the magnitude of the incidence of prolonged extubation time. The study was a single-center study with a limited sample size; hence, doing further clinical trials with a large sample size or a multicenter study may affect the outcome.

Abbreviations

AC	Anesthesia-controlled time
ASAPS	American Society of Anesthesiologist's physical status
BDZ	Benzodiazepine
BMI	Body mass index
CI	Confidence interval
DES	Desflurane
EOS	End of surgery
ET	Extubation time
ETCO2	End-tidal carbon dioxide
ETT	Endotracheal tube
GATE	General anesthesia with endotracheal intubation
IAA	Inhalational anesthetic agents
JMC	Jimma University Medical Center
MAP	Mean of arterial pressure
NMBA	Neuromuscular blocking agent
NOT	Nonoperative time
PACU	Postanesthesia care unit
TASH	Tikur Anbessa Specialized Hospital
TIVA	Total intravenous anesthesia

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Authors' contributions
G.A. Conceived the problem under the study, wrote a statement of the problem and method part, performed the analysis, and wrote the main manuscript; M.B wrote the background; A.H. wrote the significance of the study and report; W.R. and A.B. conducted the literature review, data validation, data insertion, and analysis, prepared the tables and figures of the report; G.G. and G.A. wrote the discussion and conclusion. All authors reviewed the manuscript. The authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical clearance and approval were obtained from the institutional review board of Jimma University and were brought to the office of Jimma Medical Center, OR head. Then, a formal letter of permission to conduct the study was taken. Oral informed consent was also obtained from each study participant after a clear orientation of the study objective, benefits, and procedures. Confidentiality of participant's information was kept using unique codes and medical record numbers rather than personal identification. Moreover, the data collected from each study participant were used solely for the intended purpose.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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