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Influence of paediatric overweight and obesity on emergence delirium: a prospective, observational cohort study

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Abstract

The role of preoperative body mass index (BMI) in postoperative delirium among children remains unclear. In this single-centre, prospective cohort study, 230children (6–18 years) undergoing elective non-cardiac surgery were enrolled into either Group N(normal weight) or Group O (overweight or obese) based on BMI. ED was assessed using post-anaesthesia ED scores. Postoperative pain was evaluated using the Wong–Baker scale (4–7 years) and the visual analogue scale (≥8 years) for children. Postoperative behavioural changes were assessed using the Post-Hospitalisation Behaviour Questionnaire for Ambulatory Surgery. The primary outcome was ED incidence within 45 min postoperatively. ED incidence occurred in 12/115 and 35/115 patients in Groups N and O, respectively. No differences were observed in postoperative pain incidence at 0 or 15 min between the groups. No difference was observed in behaviour questionnaire scores. ED incidence was higher in overweight and obese children and adolescents, with the highest incidence observed among obese children. The relationship between postoperative complications, obesity, and overweight requires further in-depth study.

Trial Registration

The study was registered at the Chinese Clinical Trial Registry (https//www.chictr.org.cn/bin/project/edit?pid=255239 ChiCTR2400094570).

Introduction

The prevalence of overweight and obesity varies by sex, age group, and geographical region, and remains a global health concern [1]. Obesity prevalence among children and adolescents has peaked in most high-income countries, whereas it continues to rise in many low- and middle-income countries [2]. Rising global obesity has led to a marked increase in the incidence of secondary diseases, many of which are associated with a chronic low-grade inflammatory state [3]. Paediatric obesity is increasingly common and associated with cognitive difficulties [4–9].

Postoperative delirium, including emergence delirium (ED), is a common and potentially serious postoperative complication. ED is a transient disturbance of consciousness occurring during recovery from general anaesthesia, characterised by hallucinations, delusions, and confusion, and often manifests as moaning, crying, restlessness, and thrashing in bed [10]. Vulnerability to delirium precipitated by general anaesthesia is considered higher in children that than adults [11]. Although these episodes are often short-lived, they increase the likelihood of self-injury and delayed discharge, additional nursing care, and increased medical costs, all of which are clinically concerning [10].

Body mass index (BMI) is widely used as a clinical standard for assessing excess body fat in the US and China [1, 12, 13], in addition to weight status in children and adolescents. Preoperative BMI has been identified as a risk factor for postoperative delirium in older patients [14]; however, whether it plays a similar role in children remains unclear.

The present study aimed to determine whether overweight and obese children are more susceptible to ED than normal-weight children.

Methods

Ethics statements

This manuscript adheres to the STROBE guidelines. The study was approved by the Institutional Review Board of Yichang Central People's Hospital (HEC-KYJJ- 2024-437-02), chaired by Ke-jun Yan, and was conducted in accordance with the principles of the Declaration of Helsinki on 26 January 2024. The study was prospectively registered at the Chinese Clinical Trial Registry on 24 December 2024, prior to patient enrolment. (https://www.chictr.org.cn/bin/project/edit?pid=255239; ChiCTR2400094570; principal investigator: Yuan Gong). Written informed consent was obtained from parents and/or legal guardian.

Study design and patients

This single-centre, parallel-group observational cohort study was conducted at Yichang Central People's Hospital from 24 December 2024 to 31 May 2025. The first participant was enrolled on 26 December 2024, and the final follow-up was conducted on 29 May 2025. The children included in the study were aged 6–18 years with the American Society of Anesthesiologists physical status classes I–III and scheduled to undergo elective non-cardiac surgery.

Participants were divided into two groups (n = 115 per group): Group N (normal weight) and Group O (overweight and obese). Definitions of normal weight, overweight, and obesity were based on national standards issued by the National Health and Family Planning Commission of the People's Republic of China [15]. Exclusion criteria included refusal to provide consent, allergy to any of the study drugs, pre-existing behavioural diagnoses (e.g., attention deficit hyperactivity disorder or autism), neurocognitive disorders (e.g., developmental delay, seizures, or intellectual disability), use of medications or nutraceuticals that affect blood pressure (BP) or heart rate (HR), emergency surgery, arrhythmia requiring treatment, and coronary artery disease. Preoperatively, participating children and their parents were scored with suitable anxiety scales, including the State-Trait Anxiety Inventory (STAI), the Strengths and Difficulties Questionnaire (SDQ), and the modified Yale Preoperative Anxiety Scale (m-YPAS) to identify emotional and behavioural issues of the patients [16–18]. The temperament of each participating child was additionally assessed using the emotionality, activity, and sociability (EAS) temperament survey.

Perioperative anaesthetic care

Preoperatively, all patients fasted for 6 h and refrained from clear fluid intake for 1 h. No premedication was administered before surgery. To reduce separation anxiety, children were accompanied by their parents into the operating room. Upon arrival, routine non-invasive monitoring of BP, HR, electrocardiography, pulse oxygen saturation, and bispectral index (BIS) was initiated using a multifunction monitor (GE Healthcare, Chicago, IL, USA). A 24-G intravenous catheter was inserted into the dorsal veins of the hand.

All patients were administered an intravenous bolus of lactated Ringer's solution (2 mL•kg^{-1}) for 15 min immediately before intravenous induction. Strict analgesic dosing was maintained irrespective of age or surgical procedure. After routine preoxygenation, general anaesthesia was induced according to a standardized protocol using sufentanyl (0.25 μg•kg^{-1}), propofol (2.0 mg•kg^{-1}), and rocuronium (0.6 mg•kg^{-1}) to facilitate tracheal intubation. When the eyelash reflex was absent, patients were ventilated with 100% oxygen-contained face mask. Intubation was performed at a BIS score between 40 and 60. Post-induction anaesthesia levels were maintained with 2% sevoflurane in a 50% oxygen-air mixture. The depth of anaesthesia was monitored using a BIS monitor (GE Healthcare), and the concentration of sevoflurane was adjusted to maintain a BIS score between 40 and 60. Ondansetron (0.1 mg•kg^{-1}) and dexamethasone (0.125 mg•kg^{-1}) were administered immediately after induction. During surgery, all patients were administered ibuprofen (10 mg•kg^{-1}) and tramadol (1 mg•kg^{-1}) for pain management.

Sevoflurane was discontinued at the end of the surgery. Neostigmine (0.04 mg•kg^{-1}) and atropine (0.02 mg•kg^{-1}) were administered to antagonise any residual neuromuscular blockade when the train-of-four (TOF) ratio was ≥ 0.5. Extubation was performed by an experienced anaesthetist blinded to the study, after confirming adequate tidal volume, regular spontaneous respiratory patterns, purposeful behaviour (for example, eyes open upon request), and TOF ≥ 0.9. Following extubation, patients were monitored for at least 5 min until regular spontaneous respiration was established, after which they were transferred to the post-anaesthesia care unit (PACU). Postoperative pain intensity was assessed regularly throughout the study using the Wong–Baker scale for children aged 4–7 years [19] or the visual analogue scale for those aged ≥ 8 years [20].

In the PACU, the attending researcher, blinded to the study, assessed post-anaesthesia ED and pain scores every 15 min. Continuous monitoring included electrocardiography, peripheral pulse oximetry, and non-invasive BP measurements. Patients were discharged from the PACU to the overnight ward once their steward recovery scores exceeded 4. The assessment window of 45 min was selected based on the definition of ED [21]. Rescue methods for postoperative vomiting included intravenous ondansetron (50 μg•kg^{-1}) and dexamethasone (0.1 mg•kg^{-1}) within 24 h after surgery, while rescue methods for postoperative pain consisted of sufentanyl (0.1 μg•kg^{-1}) intravenously administered in the PACU. During follow-up visits, the researcher assessed postoperative behavioural changes using the Post-Hospitalisation Behavior Questionnaire for Ambulatory Surgery (PHBQ-AS) at 3, 14, and 28 days, based on reports from patients and their parents.

Primary outcomes

The primary outcome was the incidence of ED within 45 min postoperatively. As the terms ED and emergency agitation are often used interchangeably, they were used synonymously throughout the trial. ED was defined as a Pediatric Anaesthesia Emergence Delirium score ≥ 10 [22].

Secondary outcomes

Secondary outcomes included subgroup analysis of ED, pain scores at 0, 15, 30, and 45 min, and PHBQ-AS scores at 3, 14, and 28 days.

Statistical analysis

Based on a preliminary experiment, the incidence of ED was 18.87% and 36.11% in normal-weight and overweight or obese patients, respectively. With a two-sided significance level of $\alpha = 0.05$, a sample size of 102 patients per group was required to achieve 80% power to detect a significant difference. Allowing for a 10% dropout rate, a total of 225 patients was required, resulting in approximately 115 patients per group to detect a difference between groups in the composite primary outcome measure.

The normality of the data distribution was assessed using the Kolmogorov–Smirnov test. Normally distributed data are expressed as mean ± standard deviation, whereas non-normally distributed data are expressed as median and interquartile range. Patient operation duration, anaesthesia duration, extubation time, SDQ, EAS, and STAI are expressed as mean ± standard deviation and were analysed using Student's *t*-test. Age, height, weight, BMI, and m-YPAS were analysed using the Mann-Whitney U test.

Among categorical variables, sex and surgical type were analysed using the chi-square test. For surgical type, the continuity-corrected chi-square test was used when the expected frequency in any cell was between 1 and 5; if the expected frequency was ≤ 1, Fisher's exact test was used. The primary outcome measure (postoperative delirium) was analysed using multiple binary logistic regression analysis (enter method), with age, sex, and surgical type (tonsillectomy with or without adenoidectomy) included as covariates in the model to obtain adjusted odds ratios (ORs).

Postoperative pain and PHBQ were analysed using chi-square test; if the theoretical frequency was between 1 and 5, the continuity-corrected chi-square test was used. To investigate the risk factors for ED across two or three groups, binary logistic regression analysis (enter method) was performed, and OR with 95% confidence intervals (CIs) were calculated. In each test, a two-sided P-value of < 0.05 was considered statistically significant. All analyses were conducted using GraphPad Prism 9.0 (GraphPad Software, San Diego, CA, USA).

Results

Patient characteristics

Between 24 December 2024 and 31 May 2025, 350 patients were screened, of which 230 were included in the analysis and enrolled into the two groups (Fig. 1). Patient characteristics, including age, American Society of Anesthesiologists physical status classification, and sex, and clinical data, including surgery type, surgery duration, and anaesthesia duration, did not differ between the groups. No differences in baseline values were observed between the groups, except for height and weight (Table 1).

Table 1
Patients and clinical baseline data

Variable	Group N(n = 115)	Group O(n = 115)	*P*
Sex; n(%)			
Male	63(54.78%)	77(66.96%)	0.059
Female	52(45.22%)	38(33.04%)	
Age (years); median	8.00(8.51–9.60)	9.00(9.03–10.18)	0.141
Height (cm)	134.00(134.03-141.05)	140.00(138.36-145.18)	0.046
Weight (kg); median	27.00(30.22–35.06)	42.00(42.42–49.11)	<0.0001
BMI; median	16.00(16.16–16.89)	21.43(21.23–22.50)	<0.0001
Duration of operation (min)	32.23 ± 20.49	33.64 ± 23.89	0.632
Duration of anesthesia (min)	43.15 ± 22.38	43.27 ± 24.96	0.969
Time of extubation (min); median	15.78 ± 4.70	14.50 ± 4.24	0.03
Child anxiety score			
Baseline SDQ	17.71 ± 3.81	17.95 ± 4.58	0.673
m-YPAS	23.33(28.61–35.69)	23.33(28.61–33.70)	0.107
Child temperament scores			
EAS score	55.25 ± 7.60	56.57 ± 8.54	0.219
Parental anxiety scores			
STAI score	35.13 ± 5.18	36.00 ± 6.23	0.251
Type of surgery			0.757
E.N.T	96(83.48%)	100(86.96%)	
Tonsillectomy with/without Adenoidectomy	41(35.65%)	62(53.91%)	0.005
Adenoidectomy	37(32.17%)	29(25.22%)	0.2435
Other	18(15.65%)	9(7.83%)	0.0652
Gynecological	4(3.48%)	3(2.61%)	> 0.9999
General surgery	15(13.04%)	12(10.43%)	0.5389

BMI, body mass index; EAS, emotionality, activity, and sociability; STAI, State–Trait Anxiety Inventory

Variable	Group N(n = 115)	Group O(n = 115)	*P*
Orthopedics	4(3.48%)	4(3.48%)	> 0.9999

BMI, body mass index; EAS, emotionality, activity, and sociability; STAI, State–Trait Anxiety Inventory

Primary outcomes

ED incidence in Groups N and O was 12/115 (10.43%) and 35/115 (30.43%), respectively, with a relative risk (RR) of 3.76 (95% CI: 1.83, 7.70). This difference was statistically significant (P < 0.001).

Secondary outcomes

The subgroup analysis indicated that ED incidence was higher in overweight patients (7/53, 13.21%) than that in normal-weight patients (12/115, 10.43%), with the highest incidence observed in obese patients (28/62, 45.16%). Significant differences were observed between patients with obesity and overweight (P = 0.0002; RR = 5.41; 95% CI: 2.12, 13.85) and normal-weight patients (P < 0.0001; RR = 7.07; 95% CI: 3.24, 15.41). No statistical difference was found between overweight and normal-weight patients (P = 0.598), despite an approximate 30% increase in the rate of ED. No differences were observed between groups with respect to patient anxiety scores, surgery type, surgery duration, or anaesthesia duration (P > 0.05) (Table 1). Furthermore, the incidence of postoperative pain at 0 min was higher in Group N (6.09%) than that in Group O (1.74%) (P = 0.174; RR = 0.27; 95% CI: 0.06, 1.34) (Table 2), and at 15 min was higher in Group N (6.96%) than that in Group O (3.48%) (P = 0.48; RR; 95% CI: 0.14, 1.65) (Table 3). Postoperative pain scores did not differ significantly between groups, possibly due to the limited sample size. Extubation time was shorter in Group O than that in Group N (P = 0.03; Table 1). No differences were observed in the PHBQ-AS scores at 3, 14, and 28 days (Table 4). Multivariate regression analysis identified sex, age, and surgical type (tonsillectomy with/without adenoidectomy) as risk factors for ED (Table 5). Furthermore, subgroup analysis showed that both obesity and being overweight were risk factors for ED (Fig. 2). No other complications were recorded, as the anaesthesia protocol followed the principles of general anaesthesia.

Table 2
Incidence of postoperative pain

Time (min)	Group N(n = 115)	Group O(n = 115)	*P*	RR1
0	7(6.09%)	2(1.74%)	0.174	0.27 (0.06,1.34)
15	8(6.96%)	4(3.48%)	0.374	0.48 (0.14,1.65)
30	1(0.87%)	1(0.87%)	1	1.00 (0.06,16.18)
45	0(0)	1(0.87%)	1	/

Table 3
Subgroup analysis of the incidence of postoperative pain

Time (min)	Normal weight(n = 115)	Overweight(n = 53)	Obesity(n = 62)	P
0	7 (6.1%)	1 (1.89%)	1 (1.61%)	0.235
15	8 (6.96%)	3 (5.66%)	1 (1.61%)	0.308
30	1 (0.87%)	1 (1.89%)	0	0.554
45	0	0	1 (1.61%)	0.256

Table 4
PHBQ-AS scores at 3, 14, and 28 days

Postoperative day	Group N (n = 115)	Group O (n = 115)	*P*	RR1
3	19 (16.52%)	18 (15.65%)	0.86	0.94 (0.46,1.90)
14	1 (0.87%)	1 (0.87%)	1.00	1.00 (0.06,16.18)
28	0	2 (1.74%)	0.498	/
PHBQ-AS, Post Hospitalization Behavior Questionnaire for Ambulatory Surgery				

Table 5
Logistic regression analysis of risk factors for emergence delirium

	OR	*P*
	Mean difference (95%CI)	
BMI		
Normal weight	0.26 (0.12–0.55)	0.0001
Overweight and obesity	3.85 (1.82–8.14)	
Sex		
Male	3.71 (1.61–8.58)	0.002
Female	0.27 (0.12–0.62)	
Age (year)	0.88 (0.78–0.10)	0.044
OR, odds ratio; CI, confidence interval; BMI, body mass index		

Discussion

In this study, we determined whether overweight and obese children are more prone to ED than normal-weight children. We found that children and adolescents who were obese or overweight had higher ED incidence, with a stronger association observed in obese patients than that in normal-weight patients. The incidence of postoperative pain at 0 and 15 min was higher in normal-weight children than that in overweight or obese patients, although this difference was not statistically significant.

The higher ED incidence observed in overweight and obese children and adolescents may involve multiple factors. First, inflammation and insulin resistance have been linked to exaggerated cognitive impairments [23–25], and neuroinflammation is an important pathogenic mechanism [26]. A past history of obesity predisposes individuals to neuroinflammation [27]. Second, paediatric obesity has been associated with differences in cognition, brain structure, and brain function [28]. Third, the prefrontal cortex, which is involved in cognitive control, undergoes substantial maturation and remains highly plastic throughout adolescence [29].

Severe paediatric obesity, defined as body weight > 120% of the 95th percentile or a BMI > 35 $kg \bullet m^{-2}$, may be a significant predictor of ED in children [30, 31]. However, this definition applies to only a small proportion of children, despite nearly 20% of children and adolescents aged 6–17 years being overweight or obese, with prevalence continuing to rise. Our study demonstrated the negative effects of overweight and obesity in the context of paediatric and adolescent ED. Subgroup analysis showed a higher incidence of ED in both overweight and obese patients than in normal-weight patients, although the difference between the overweight and normal-weight groups was not significant.

The influence of being overweight and obesity on paediatric and adolescent health warrants careful consideration, particularly in children undergoing surgery and anaesthesia. Given the links between obesity, impaired cognition, and cognitive decline [32, 33], interventions targeting paediatric and adolescent obesity may help reduce long-term cognitive risk.

Previous studies have identified several risk factors that may be linked to ED, including general anaesthetic agents, surgery type, ethnicity, age, and pre-hospital anxiety, although supporting evidence remains limited [34]. Furthermore, general anaesthetics have been demonstrated to exert negative effects at every stage of neurodevelopment, with long-lasting neurocognitive consequences in immature animal models during periods of rapid brain growth [35]. The variability in anaesthetic agents limits the investigation of their effects on ED, as implementing a standardised anaesthesia protocol is difficult, particularly in multicentre trials. Nonetheless, the single-centre design helps minimize this limitation. Postoperative pain is another risk factor associated with ED. In our study, the same anaesthetic protocol was used, resulting in similar postoperative analgesic effects. Nevertheless, differences in postoperative pain incidence were observed between the groups. This finding may be attributed to greater lipid solubility of analgesics and the higher proportion of adipose tissue in patients. Additionally, surgical intervention in paediatric patients may induce psychological stress, potentially leading to behavioural changes during the perioperative period and after hospital discharge [36]. In this trial, no difference in the surgical type, anaesthesia duration, or surgery duration was observed between the groups. This may be

attributable to the single-centre setting where the range of procedures is relatively consistent, with ear, nose, and throat (ENT) surgery being the most common. Preoperative anxiety is another risk factor linked to the development of postoperative ED [37]. In this study, parents were allowed to accompany children into the operating room to reduce separation anxiety. Suitable anxiety scores were used to investigate the difference in anxiety levels between the patients and their parents. No differences in anxiety scores were observed between the groups, consistent with findings from our preliminary study. Children's temperament was assessed using the EAS temperament survey, which indicated that children's anxiety may also be influenced by parental anxiety. No differences were observed in the PHBQ-AS scores, which is consistent with the short-lived nature of ED. However, the long-term behavioural consequences of ED remain unclear and warrant further exploration.

Notably, extubation time was longer in Group N than that in Group O. However, the subgroup analysis showed that extubation time was shorter in overweight patients than that in obese or normal-weight patients. These findings may be explained by the high lipid solubility of opioids and general anaesthetics. Because most analgesics and anaesthetics are highly lipophilic, adipose tissue increases their volume of distribution. A certain proportion of adipose tissue may therefore delay drug clearance.

No differences in the incidence of adverse events were observed during the trial, likely because standardized anaesthesia and surgical protocols were consistently followed. Additionally, baseline characteristics were comparable between the groups. ED incidence was higher in patients with a lower incidence of postoperative pain than that in patients with a higher incidence of postoperative pain. This finding may suggest that postoperative pain is not a risk factor for ED. However, this interpretation remains speculative and, therefore, requires further investigation to clarify the relationship between postoperative pain and ED.

This study has some limitations. First, participants were enrolled as either normal weight, overweight, or obese; there were no underweight children in the study cohort. Second, the study was a single trial with limited power; hence, future multi-centre trials are needed to further validate the effects of overweight and obesity in children and adolescents. Third, in the subgroup analysis, the sample size of both the overweight and obese groups was smaller than that of the with normal-weight group, which may have affected the study results. Lastly, although the preliminary study design considered the potential influence of surgical type, no significant effect was observed. This may be because most procedures in the trial were performed in the ENT department, resulting in a relatively homogeneous surgical population.

In summary, overweight and obese children and adolescents exhibited a higher ED incidence compared with their normal-weight counterparts. ED incidence in children with obesity was highest in the subgroup analysis. The relationship between postoperative complications, obesity, and overweight requires further in-depth study. Comprehensive preoperative, intraoperative, and postoperative strategies have demonstrated potential in decreasing the incidence and duration of postoperative delirium [38].

Governments worldwide should prioritise this global health problem and implement strategies to address its associated harms.

Declarations

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Authors' contributions: MCD and KXY: data curation. GCQ and MCD: software and formal analysis. XL and GCQ: project administration. XL and JJJ: resources and investigation. YG: methodology, supervision, and validation. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

Data availability statement: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

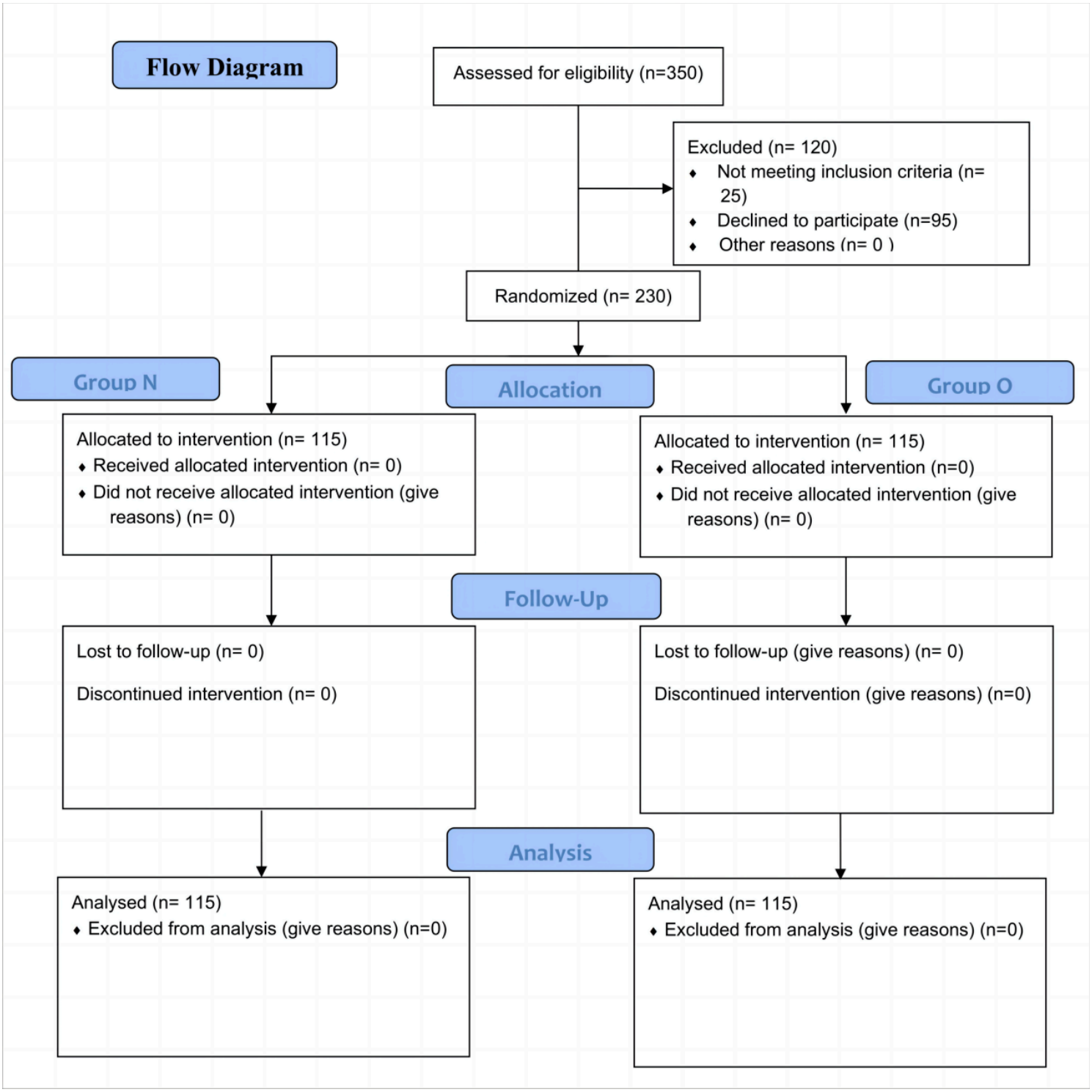


Figure 1

Flow diagram

Exposure	OR	95%LCI	95%UCI
overweight	1.54	0.55	4.3
obesity	6.5	2.84	14.85
male	3.06	1.29	7.24
female	0.33	0.14	0.78
age(year)	0.89	0.79	1.01
Tonsillectomy with/ without Adenoidectomy	1.12	0.54	2.34

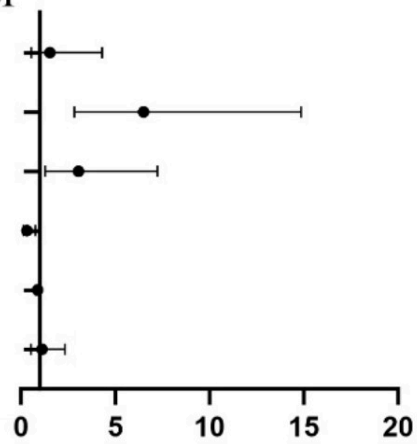


Figure 2

Subgroup logistic regression analysis of risk factors for emergence delirium

OR, odds ratio; LCI, lower confidence interval; UCI, upper confidence interval