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REVİEWS

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Are code blue calls being used appropriately?

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ABSTRACT

Aims: The aim of this study is to emphasize the importance of the blue code system, identify existing deficiencies in its implementation, and contribute to efforts aimed at addressing these shortcomings. Additionally, the study seeks to determine the rate of unnecessary and incorrect blue code activations and contribute to reducing such cases.

Methods: A total of 565 patients were included in the study by retrospectively reviewing the Code Blue Incident Reporting Forms at the University of Health Sciences Kayseri Training and Research Hospital between January 1, 2016, and May 5, 2018.

Results: Of the 565 patients included in the study, 49.9% (n=284) were female and 51.1% (n=285) were male. The mean age was 67.9±18,06 years; for females and 67.53±18.62 years for males 68.89±16,79 years. The average response time for the resuscitation team to reach the patient was 83.02±51.76 seconds. When the units initiating the blue code calls were analyzed, 54% (n=305) originated from intensive care units (ICU). In our hospital, 71.7% (n=405) of blue code calls were evaluated as incorrect activations. The most common reason for blue code activation was respiratory failure/desaturation, accounting for 52% (n=294) of the cases. Cardiac arrest was the second most common cause, observed in 27.7% (n=155) of the cases. The most frequently performed intervention was endotracheal intubation, conducted in 50.4% (n=285) of patients. Among patients who received cardiopulmonary resuscitation, 52.3% (n=81) resulted in death.

Conclusion: We found our code blue team to be successful in providing early intervention to patients; however, the rate of incorrect code activations in our hospital was found to be high. For the blue code system to function effectively, it is crucial for hospital administrations to provide continuous training to healthcare personnel and the implementation of appropriate regulatory measures.

Keywords: Code blue, cardiopulmonary resuscitation, cardiac arrest, early warning score

INTRODUCTION

The “code blue“ system is implemented to initiate cardiopulmonary resuscitation (CPR) in individuals whose vital functions such as respiration and circulation are at risk or have ceased. To operate the code blue system, hospitals have established specialized teams typically consisting of physicians, nurses, anesthesia technicians, support staff, and security personnel.[1] The code blue protocol was first defined and introduced in the 1990s at the Bethany Medical Center in Kansas, USA.[2] It has since become a widely adopted emergency code worldwide, where the same color is used to indicate the same type of emergency situation. In hospitals, the blue code is typically activated by dialing the number 2222. Upon receiving the call, the code blue team aims to reach the patient within the shortest possible time-ideally within three minutes. The team is responsible for initiating, continuing, and terminating the CPR process as appropriate. The code blue team documents patient findings and interventions using a standardized Code Blue Incident Report Form, which is archived by the hospital’s quality management unit.[3] Hospital administrations are also responsible for providing training and conducting regulatory and supervisory activities related to the code blue system.

According to current reports, the incidence of in-hospital cardiac arrest (IHCA) varies across institutions and countries. Denmark’s national DANARREST registry reported a

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cardiac arrest rate of 1.8 per 1.000 hospital admissions or 0.6 per 1.000 inpatient days between 2017 and 2018.[4] The United Kingdom's National Cardiac Arrest Audit (NCAA) reported an annual incidence ranging from 1.0 to 1.6 per 1.000 hospital admissions between 2011 and 2021.[5,6]

The aim of this study is to emphasize the importance of the code blue system, to identify deficiencies in our hospital's code blue practices by comparing them with data from the global literature, and to contribute to future improvement efforts. Additional goals include enhancing the effective utilization of a well-organized code blue team, determining the frequency of unnecessary and inappropriate code blue activations in order to help reduce them, and ultimately contributing to a reduction in in-hospital mortality from cardiopulmonary arrests through an efficiently structured and coordinated team approach.

METHODS

The study was conducted with the permission of the Kayseri City Hospital Medical Specialization Ethics Committee (Date: 08.01.2021, Decision No: 46). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

This study was conducted at the University of Health Sciences Kayseri Training and Research Hospital. The data were obtained by retrospectively reviewing the Code Blue Incident Reporting Forms archived by the Quality Management Unit, recorded between January 1, 2016, and May 5, 2018. The study includes adult patients who received a code blue call and had a completed reporting form. Pediatric patients, false code clue calls, and patients with incomplete data in the Code Blue Incident Reporting Forms were excluded from the study.

Within our hospital, there were a total of seven code blue teams, each consisting of a specialist physician (typically an anesthesiologist or a physician from another department acting as the team leader), an anesthesia technician, and a security officer.

In this study, patient age, sex, the unit initiating the code blue call, time of the call, response time of the resuscitation team, reason for the blue code blue activation, interventions for patients, decisions made by the resuscitation team regarding their subsequent follow-up were analyzed. CPR intervention performed on patients experiencing cardiac arrest, which includes both chest compressions and airway management techniques. Therefore the interventions were not classified separately as chest compressions or airway techniques such as endotracheal intubation within the CPR group. Endotracheal intubation intervention was also performed in patients who did not develop cardiac arrest but required emergency airway management due to desaturatin or respiratory failure. Other interventions were performed simple intervention such as oxygen therapy, intravenous line placement, and intravenous fluid administration), as well as medications administered other than adrenaline (including steroids, antihistamines, and anticonvulsants). Aditionally, data from patients who experienced cardiac arrest were analyzed to determine whether they achieved return of spontaneous circulation (ROSC) or if the event resulted in death.

Statistical Analysis

The data obtained in the study were analyzed using the SPSS 22.0 software package (IBM SPSS Statistics for Windows, Version 22.0; IBM Corp., Armonk, New York, USA). Frequencies, percentages, means, and standard deviations were used for the statistical analysis.

RESULTS

Data from 663 patients for whom a blue code was activated were initially evaluated. However, 34 pediatric patients and 7 cases identified as false blue code activations were excluded from the study. Additionally, 57 patients were excluded from the study due to missing data in the Code Blue Incident Reporting Forms In total, the study included data from 565 patients. In the study, 49.9% (n=284) were female and 51.1% (n=285) were male. The mean age was 67.9±18.06 years; for females and 67.53±18.62 years for males 68.89±16.79 years. The average response time for the resuscitation team to reach the patient was 83.02±51.76 seconds. Among the code blue calls, 28.3% (n=165) occurred during working hours (weekdays between 08:00 and 16:00), while 71.7% (n=404) occurred outside working hours (weekdays between 16:00 and 08:00, and weekends between 08:00 and 08:00) (Table 1).

Table 1. Demographic data

Variable	
Female, n (%)	284 (49.9%)
Male, n (%)	285 (51.1%)
Age (total), mean±SD	67.94±18.06 years
Age (female), mean±SD	67.53±18.62 years
Age (male), mean±SD	68.89±16.79 years

The data are presented as mean and number (%), SD: Standard deviation.

When the units initiating the blue code calls were examined, 54% (n=305) originated from intensive care units, 26.9% (n=152) from inpatient wards, 7.6% (n=43) from imaging centers, 4.6% (n=26) from outpatient clinics, another 4.6% (n=26) from interventional procedure areas (e.g., blood collection units, hemodialysis units, interventional radiology rooms), and 2.3% (n=13) from the emergency department (Table 2).

Table 2. Units triggering code blue calls

Unit	Number (n)	Percentage (%)
Intensive care units	305	54.0%
Inpatient wards	152	26.9%
Imaging centers	43	7.6%
Outpatient clinics	26	4.6%
Interventional procedure areas	26	4.6%
Emergency department	13	2.3%

The data are presented as number and percentage.

In our hospital, 71.7% (n=405) of the code blue activations were evaluated as inappropriate, while 28.3% (n=160) were considered appropriate activations (Figure).

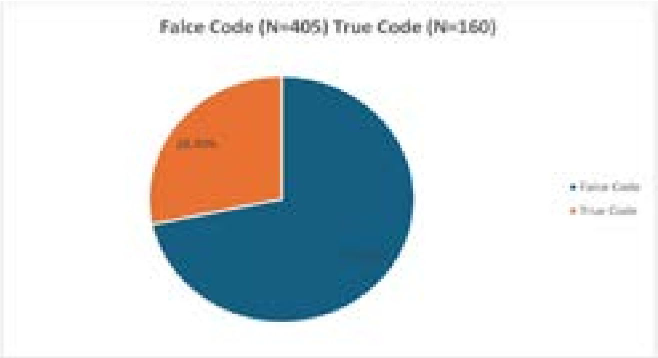

Figure. Appropriateness rates of code blue calls

When analyzing the reasons for code blue calls, respiratory failure/desaturation accounted for 52% (n=294), cardiac arrest for 27.7% (n=155), clinical deterioration for 8.7% (n=49), hypotension for 4.4% (n=25), epileptic seizures for 3% (n=17), syncope/presyncope for 1.4% (n=8), conversion disorder for 1.1% (n=6), suspected drug allergy or anaphylaxis for 0.9% (n=5), respiratory arrest for 0.9% (n=5), and altered level of consciousness for 0.2% (n=1) (Table 3).

Table 3. Reasons for blue code activation

Reason for call	Number (n)	Percentage (%)
Respiratory failure/low oxygen saturation	294	52.0%
Cardiac arrest	155	27.7%
Patient deterioration	49	8.7%
Hypotension	25	4.4%
Epileptic seizure	17	3.0%
Syncope/presyncope	8	1.4%
Conversion disorder	6	1.1%
Drug allergy or anaphylaxis concern	5	0.9%
Respiratory arrest	5	0.9%
Altered consciousness	1	0.2%

The data are presented as number and percentage.

When the interventions administered to patients were examined, 50.4% (n=285) underwent endotracheal intubation due to respiratory failure/desaturation without receiving CPR (endotracheal intubations performed on patients who experienced cardiac arrest were not included in this rate.), 27.7% (n=155) received CPR, and in 12% (n=68) of the cases, no intervention was performed. Simple interventions such as nasal oxygen administration, intravenous line placement or intravenous fluid administration were carried out in 8% (n=45) of patients. In 3% (n=17) of the patients, medications such as steroids, antihistamines, and anticonvulsants were administered (Table 4).

When the outcomes of the patients for whom a code blue was activated and the decisions made by the resuscitation team regarding their subsequent follow-up were analyzed, it was found that 63.4% (n=358) of the patients continued to be monitored in their current location, 14.3% (n=81) resulted in death, 11.7% (n=66) were transferred to the intensive care unit, 8.8% (n=50) were transferred to the emergency department for observation, 1.4% (n=8) were referred to an external facility, 0.2% (n=1) were admitted to an inpatient ward, and 0.2% (n=1) underwent emergency surgery (Table 5).

Table 4. Interventions performed

Intervention	Number (n)	Percentage (%)
Endotracheal intubation[1]	285	50.4%
Cardiopulmonary resuscitation (CPR)	155	27.7%
No intervention	68	12.0%
Simple intervention	45	8.0%
Medication	17	3.0%

The data are presented as number and percentage.
Emergency endotracheal intubation performed in patients with respiratory failure/desaturation without cardiac arrest. Endotracheal intubations performed on patients who experienced cardiac arrest were not included in this rate.
Simple intervention: Administration of nasal oxygen, IV line placement, fluid administration.
Medication: Steroids, antihistamines, anticonvulsants

Table 5. Code blue follow-up decisions

Decision	Number (n)	Percentage (%)
On-site follow-up	358	63.4%
Death (exitus)	81	14.3%
Transfer to intensive care	66	11.7%
Transfer to emergency service	50	8.8%
External referral	8	1.4%
Transfer to ward	1	0.2%
Emergency surgery	1	0.2%

The data are presented as number and percentage

Among the patients who underwent CPR, 52.3% (n=81) resulted in death, 29.7% (n=46) achieved return of ROSC, and 18.1% (n=28) were handed over to the on-site medical team for further intervention and decision-making before the CPR outcome could be determined (Table 6).

Table 6. Cardiopulmonary arrest outcomes

Outcome	Number (n)	Percentage (%)
Death (exitus)	81	52.3%
Return of spontaneous circulation (ROSC)	46	29.7%
Outcome unknown/pending	28	18.1%

The data are presented as number and percentage.

DISCUSSION

The blue code is a rapid response system developed for the emergency resuscitation and stabilization of patients within a hospital who have experienced, or are at risk of, cardiac or respiratory arrest.[7] In Turkiye, among the objectives of " Code Blue Management," which is included in the Ministry of Health's hospital quality standards, is to reduce in-hospital mortality and morbidity by ensuring that a well-trained emergency response team reaches patients in the shortest possible time.

Studies have shown that survival rates after cardiac arrest decline with increasing age, particularly after the age of 70.[8] In studies conducted in Turkiye, similar to our findings, Özbilgin et al.[9] reported a mean patient age of 63.76±19.77, and Kayır et al.[10] reported a mean age of 73.8. Although IHCA is more common among male patients, clinical outcomes are reported to be similar between men and women.[11] In line with the literature, our study also found that 49.9% were female and 51.1% were male.

One of the most critical factors influencing the success of a code blue intervention is early response. It has been demonstrated that CPR administered within the first 3-4 minutes yields significantly better outcomes.[12,13] In our study, the average response time to reach the patient was 83.02 seconds (1.38 minutes), indicating that the code blue system in our hospital is implemented within the target timeframe and in accordance with quality standards, allowing for timely intervention. Studies conducted in Turkiye show variability in response times. Esen et al.[14] reported a longer response time of 3.45 minutes compared to our study. On the other hand, Özütürk et al.[15] reported a shorter response time than ours, reaching patients in 1.1 minutes.

Other factors influencing the success of CPR include whether the patient was being monitored at the time of arrest, whether the initial rhythm was ventricular tachycardia or fibrillation, the absence of the need for tracheal intubation, normal cerebral performance, and the absence of comorbidities such as chronic obstructive pulmonary disease (COPD), acute kidney failure, and sepsis.[16] In our study, the majority of code blue calls (54%) originated from intensive care units. Patients in these units tend to have more comorbid conditions compared to those in inpatient wards or receiving outpatient care. This higher burden of comorbidity negatively impacts post-cardiac arrest survival rates.

False code blue activations can negatively affect the motivation of code blue teams and lead to unnecessary workforce burden. In our study, the rate of inappropriate code blue calls was recorded as 71.7%. A code was considered appropriate if it was initiated for a patient experiencing cardiac and/or respiratory arrest. In the directive published in 2017 regarding code blue practices, it is stated that "code blue calls are not issued in units such as emergency departments, intensive care units, and operating rooms".[17] Intensive care units are expected to have the medical equipment, tools, knowledge, and skills necessary to intervene in deteriorating patients. Therefore, code blue calls made for patients in the ICU who require urgent intervention due to desaturation or respiratory failure without experiencing cardiac arrest have been considered inappropriate. In our hospital, the primary source of false code blue activations was intensive care units. Additionally, the most frequent reason for initiating a code was consultation for elective endotracheal intubation due to respiratory failure or desaturation. Among all interventions performed, endotracheal intubation was the most common procedure, conducted in 50.4% of cases. Endotracheal intubations performed in patients who developed cardiac arrest were not included in the total count of intubations presented in this study; therefore, the actual intubation rate is likely to be higher. These findings suggest that healthcare staff working in intensive care units may lack sufficient experience and confidence in performing intubation independently. Moreover, in some ICUs within our hospital, specialist physicians are assigned to multiple areas, which may delay the response to deteriorating patients. We believe that, in our hospital practice, healthcare professionals working in the intensive care units have developed the incorrect habit of initiating code blue calls for patients whose condition is deteriorating. As a result, staff may prefer to activate the code blue system, perceiving the experienced and well-equipped code blue team as a safer, easier, and more reliable option for urgent interventions.

Some studies have excluded code blue calls from intensive care units from their analyses due to methodological concerns. In a study by Çiçekci et al.[18] 42% of the code blue calls originated from ICUs, with the cardiology ICU being the most frequent source. In another study by Eroğlu et al.[19] the rate of false code blue calls was reported as 91%, higher than in our study. They attributed the high rate of inappropriate activations to staff anxiety and pressure from patients' relatives. In the study by Baytar et al.[20] the rate of inappropriate code blue calls was 42.9%, with the most common reason for activation being syncope.

Mortality rates reported in the literature vary between 0% and 42%. In large-scale studies, the overall survival and hospital discharge rates following CPR are approximately 20%, and this rate has been increasing over the past two decades.[21]

In our study, 52.3% of the patients who received CPR resulted in exitus. Considering patients whose CPR outcome could not be evaluated due to early handover to the on-site team, it is estimated that the actual mortality rate in our hospital may be even higher. Çakırca et al.[22] reported a higher mortality rate than ours, with 88.9% of patients who experienced cardiac arrest not surviving.

The 2021 guidelines of the European Resuscitation Council recommend that hospitals implement and monitor early warning score systems to identify patients whose condition is deteriorating or who are critically ill. This is because both in-hospital and out-of-hospital cardiac arrests are often preceded by warning signs, some of which may be preventable.[23] In a study by Lee et al.[24] the implementation of medical emergency teams (rapid response teams) led to a decrease in code blue activations in medical units, from 3.55 to 0.96 per 1.000 admissions during periods when these teams were actively operating. Furthermore, hospitals with well-organized team, where team roles are clearly defined, communication is effective, leadership is strong, training is continuous, and unannounced drills are regularly conducted have been shown to experience lower in-hospital mortality rates.[25]

Limitations

There are certain limitations in our study. Due to incomplete documentation in the code blue notification forms, data regarding the initial rhythms, medications administered, and the duration of CPR in patients who experienced cardiac arrest could not be analyzed. Additionally, in some patients, the outcome of CPR was not observed, which may have led to an overestimation of the mortality rate. Furthermore, among patients who achieved return of ROSC, outcomes such as neurological deficits or discharge to home were not evaluated.

CONCLUSION

As a result, the code blue system is an essential component of hospital quality standards. For this system to function effectively, hospital administrations should provide continuous training to their staff, enhance the knowledge, skills, and confidence of other physicians in managing patients experiencing cardiac arrest, establish an adequate staffing level of code blue teams to ensure to rapid response to patients, and implement early warning score systems. We believe that these measures can contribute to reducing the incidence of IHCA and associated mortality.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of the Kayseri City Hospital Medical Specialization Ethics Committee (Date: 08.01.2021, Decision No: 46).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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The effect of dominant hand on laryngoscope use in medical students*

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ABSTRACT

Aims: This study investigates the effect of hand dominance on endotracheal intubation performance among medical students with no prior intubation experience, focusing on procedural time, success rates, glottic visualization, and subjective difficulty. The hypothesis was that right-hand dominant individuals would perform the intubation faster due to the ergonomic advantages of standard intubation equipment designed for right-handed use.

Methods: A cross-sectional study was conducted with 14 medical students (7 right-hand dominant, 7 left-hand dominant) from a university. Participants received standardized training before performing intubation on a mannequin using a standard left-hand Macintosh laryngoscope. Intubation time, number of attempts, percentage of glottic opening (POGO), Cormack-Lehane grade, and subjective difficulty (Likert scale) were recorded. Statistical analysis was conducted using Jamovi software, with $p<0.05$ considered significant.

Results: Right-hand dominant individuals achieved significantly shorter intubation times than left-hand dominant ones (median 26 vs. 59 s; $p=0.029$). Although the first-attempt success rate was higher in the right-handed group (85.7 vs. 57.1%), the difference was not statistically significant. No significant differences were found in POGO scores, Cormack-Lehane grades, or subjective difficulty ratings, although trends indicated that left-handed individuals experienced greater difficulty and inferior glottic visualization.

Conclusion: The study demonstrates that standard intubation equipment ergonomically favors right-hand dominant individuals potentially leading to more efficient procedural performance. These findings highlight the need for inclusive training strategies and equipment design considerations that accommodate hand dominance, thereby improving educational outcomes and patient safety in airway management.

Keywords: Hand dominance, intubation, laryngoscopy, left hand, right hand.

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INTRODUCTION

Endotracheal intubation is a complex procedure that plays a critical role in establishing the airway and requires a high level of visual, cognitive and motor skill coordination.[1,2] The success of the procedure directly depends not only on theoretical knowledge but also on the practitioner's manual dexterity, visual-motor coordination and habits.[3] Especially in laryngoscope use, dominant hand preference stands out as an important individual factor that may affect intubation performance.[4] Standard laryngoscopes are designed for right-handed use, with the handle held in the left hand by right-handed users, which creates an ergonomic advantage for right-hand dominant individuals and a disadvantage for left-handed individuals in educational settings.[5]

The effect of hand dominance on applied skills has been emphasized in studies conducted in pediatric and emergency

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care fields, and it has been shown that motor learning and ergonomics play a decisive role in procedural performance and patient safety.[1,6] Some studies have reported that the dominant hand provides an advantage in technical control and glottic view,[3] while others have shown that intubation can be performed with the non-dominant hand as well.[4] Despite all these findings, the number of studies directly comparing performance differences between individuals with right-and left-hand dominance and no intubation experience under standard conditions is quite limited.

The aim of this study was to evaluate whether there is a difference in intubation time, success rate, achievement of glottic view and procedural difficulty between right and left hand dominant medical students with no intubation experience. Accordingly, the study aims to contribute to the restructuring of educational materials that consider individual differences and to a better understanding of technical difficulties reflected in clinical practice. It is anticipated that the findings will lay the groundwork for the development of more inclusive and personalized intubation training strategies by revealing the difficulties faced by left-hand dominant individuals during standard laryngoscopy. The hypothesis of our study is that right-hand dominant individuals will have better intubation performance regarding the procedure time, as the standard intubation equipment is ergonomically designed for right-handed users.

METHODS

For this cross-sectional study permission was obtained from Marmara University Clinical Researches Ethics Committee (Date: 08.12.2023, Decision No: 09.2023.1691). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. A total of 14 students, seven with right dominant hand and seven with left dominant hand, who were studying at Marmara University Faculty of Medicine and had no previous intubation experience, were included in the study. The study was conducted in the student laboratory of the university. Exclusion criteria were having received training on intubation, having watched a training video, having performed intubation on a patient or mannequin, and having any pathology that would affect hand-eye coordination for the procedure. This study was supported by TÜBİTAK Scientist Support Programs Presidency within the scope of the 2209-A University Students Research Projects Support Program (No: 1919B012317940).

Prior to the procedure, participants were clearly informed that the study aimed to examine the role of hand dominance in intubation performance, ensuring they understood the study's purpose. This was followed by a ten-minute theoretical training course on endotracheal intubation provided by the researcher (R.A.) to standardize the instructions given to all participants. Airway anatomy, indications for endotracheal intubation, airway assessment and intubation techniques were explained. Demographic and anthropometric data of the students were recorded. Then, intubation was performed on an airway model (Laerdal Medical, Stavanger, Norway). Intubation was performed with a standard Macintosh number 4 laryngoscope (Heine Classic+, Heine Optotechnik, Herrsching, Germany) with the handle held in the left hand and the blade opening to the right. During the laryngoscopy procedure, the practitioners were asked to state the percentage of glottic opening (POGO) and Cormack-Lehane grade. Intubation was then performed and the balloon of the endotracheal tube (ETT) was inflated. The success of intubation was confirmed by applying positive pressure through the ETT with a balloon-valve-mask and inflation of the lungs, which were clearly visible on the model. The time from the handling of the laryngoscope by the practitioner to the inflation of the ETT balloon was recorded. Intubation success was recorded. In case of unsuccessful intubation, the practitioner repeated the procedure again. This continued until successful intubation was achieved and the number of attempts was recorded. Finally, a subjective evaluation of the intubation procedure by the practitioner was performed. For this, a likert scale from 1 to 5 was used (1-very easy, 2-easy, 3-moderate, 4-difficult, and 5-very difficult).

For POGO, we looked at how much of the glottis opening was visible. To avoid confusion, the practitioners were asked to mark this opening as 100% (full opening visible), 75%, 50%, 25% or 0% (no opening visible at all), whichever value was closest to these numbers. The Cormack-Lehane grade was assessed as the standard; 1-glottis fully visible; 2-glottis partially visible; 3-glottis not visible, only epiglottis visible; 4-neither glottis nor epiglottis visible.

Statistical Analysis

Jamovi software was used for statistical analysis (The Jamovi Project (2022). Jamovi. (Version 2.3) [Computer Software]. Retrieved from https://www.jamovi.org.). In descriptive analyses, mean±standard deviation, and median and interquartile range (IQR) were used for normal and non-normally distributed variables, respectively. Intergroup comparisons for continuous variables were made with Student t, Welch and Mann-Whitney U tests in independent groups. Fisher's exact test was used to analyze categorical variables. $p<0.05$ was considered statistically significant. The primary outcome measure of our study was intubation time. Secondary outcome measures were the number of intubation attempts, Cormack-Lehane grade, POGO and objective measure of intubation difficulty. For the sample size calculation, the data obtained from observations on right and left dominant handed students were taken as reference. No literature data could be found in this regard. Effect size was calculated to be 2, from the preliminary investigation on four patients, two right- and two left-handed. Based specifically on endotracheal intubation times, it was calculated that a total of 12 patients, six in each group, were required for an effect size of 2, a type-1 error of 0.05 and 80% power of the study. We planned to complete our study with a total of 14 participants, seven in each group. It should be noted that this effect size estimate was derived from a very small preliminary observation involving only four participants (two right-hand dominant and two left-hand dominant). Therefore, this calculation should be considered exploratory, and the precision of the estimate is limited. Larger sample sizes are needed in future studies to provide a more robust and generalizable effect size.

RESULTS

The study was completed with a total of 14 participants, 7 males and 7 females, with a median age of 21.5 years (21-22). The characteristics and intubation parameters of the participants according to dominant hand use are given in Table. Demographic and anthropometric measures were comparable between the two groups. Intubation duration times were between 17 and 51 seconds in group R and between 26 and 350 seconds in group L (Figure 1). There was a significant difference between the two groups in this regard (26 vs. 59 s, p=0.029, Mann-Whitney U). The number of intubation attempts was observed to be between 1 and 2 in group R and between 1 and 6 in group L. While 6 (85.7%) of the intubations in group R were successful on the first attempt, this number in group L was 4 (57.1%) (Figure 2). In this context, although there was a mathematical difference between the two groups, this difference was not statistically significant (p=0.559, Fisher's exact test).

Table. General information and intubation parameters of right-and left-hand dominant students

	Group R (n=7)	Group L (n=7)	p
Age (year)	21.7±0.76	21.4±0.98	0.552S
Gender (male/female)	4/3	3/4	>0.9F
Height (cm)	173.4±8.9	176.3±14.7	0.669S
Body weight (kg)	67.4±7.2	67.7±12.9	0.960W
Intubation time (sec)	26 (24.5-37.0)	59 (31.5-132.5)	0.029M*
Intubation attempts	1 (1-1)	1 (1-3)	0.229M
1	6 (85.7)	4 (57.1)	0.559F
≥2	1 (14.3)	3 (42.9)	
Cormack-Lehane grade	1 (1-2)	2 (1-2)	0.659M
POGO (%)	100 (50-100)	50 (50-75)	0.253M
Intubation difficulty (Likert 1-5)	2 (1.5-2)	3 (2-3)	0.156M

Continuous data are presented as mean±standard deviation or median (25th-75th percentiles). Categorical data are presented as number or number (%). Group R: right-hand dominant individuals, Group L: left-hand dominant individuals, POGO: Percentage of Glottic Opening, S: Student's t test, F: Fisher's exact test, W: Welch test, M: Mann-Whitney U test. For the Cormack-Lehane grade and POGO, refer to the text. *p<0.05.

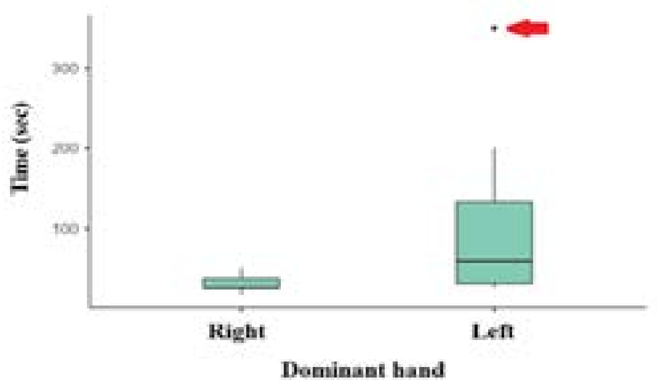

Figure 1. Intubation time. The red arrow indicates the practitioner who performed intubation in 350 seconds in the left-hand dominant group. Significant difference between the groups (p=0.029, Mann-Whitney U test).

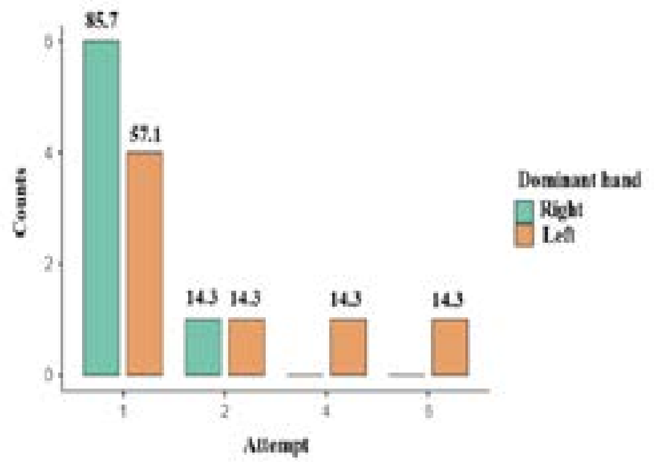

Figure 2. Number of attempts. Although left-handed individuals tended to have more attempts, there was no significant difference between the two groups (p=0.559, Fisher's exact test).

The Cormack-Lehane grades and percentages of glottic opening in relation to the airway appearance created by the practitioners on the model during the intubation procedure are presented in Figure 3. Although the glottic appearance tended to be worse in Group L, there was no significant difference between the two groups (p=0.659 and 0.253 for Cormack-Lehane grade and POGO, respectively, Mann-Whitney U test).

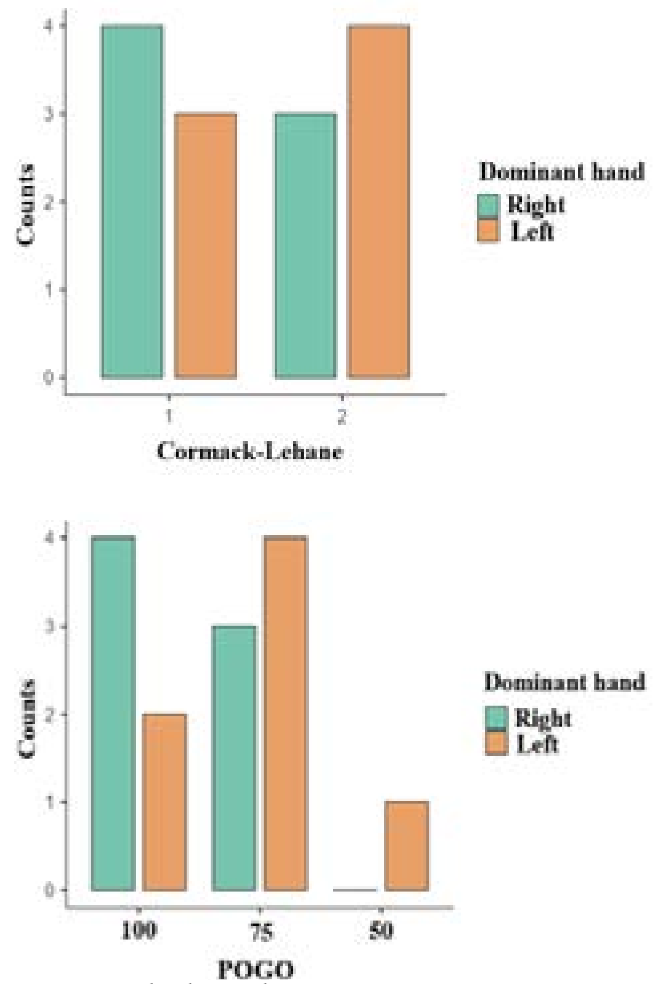

Figure 3. Cormack-Lehane and POGO views.
POGO: Percentage of Glottic Opening. Both parameters were comparable between the groups (p=0.659 and 0.253, respectively, Mann-Whitney U test).

In terms of subjective intubation difficulty, the procedure tended to be very easy or easy in Group R, while in Group L it was more likely to be moderately difficult or very difficult; however, no significant difference was observed between the two groups (p=0.156, Mann-Whitney U test; Figure 4).

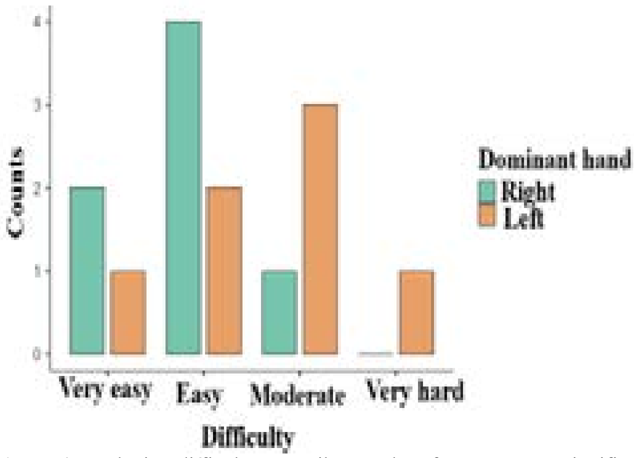

Figure 4. Intubation difficulty. For Likert scale refer to text. No significant difference between the groups (p=0.156, Mann-Whitney U test).

DISCUSSION

This study aimed to multidimensionally evaluate the effect of hand dominance on intubation performance in medical students with no intubation experience. The findings revealed that right-hand dominant individuals achieved more advantageous results in terms of intubation time in the traditional practice of using the standard laryngoscope with the left hand. This may be explained by the design of intubation equipment to favor right hand dominance.

Looking at the intubation time, which was the primary outcome of our study, it was observed that right-hand dominant individuals completed the procedure in a significantly shorter time compared to left-hand dominant ones. This finding suggests that motor adaptation between the dominant hand and the equipment directly contributes to the speed of the procedure and technical fluency. Indeed, Carlson et al.[2] in their study based on motion analysis demonstrated that dominant hand use decreased intubation time with shorter and more controlled motor movements. This finding aligns with the significant time advantage observed in right-hand dominant individuals in our study. Kerrey et al.[7] reported that the use of dominant hand was a determinant of the duration of the procedure regardless of the practitioners' level of experience. However, since our study was conducted only with participants without intubation experience, it was not possible to make a direct comparison with this result based on experience level.

The secondary outcome measures of our study included the number of intubation attempts, Cormack-Lehane grade, POGO scores and objective measures of intubation difficulty. Although there was no statistically significant difference between the groups in terms of the number of intubation attempts, it was observed that the success rate in the first attempt was higher in right-hand dominant individuals than in left-hand dominant individuals. Motor adaptation may contribute not only to the duration but also to the efficiency of the procedure. Similarly, Damore et al.[1] reported that left-hand students progressed more slowly in procedural skill learning. This finding is in line with the fact that left-hand dominant participants in our study showed a tendency for lower performance in intubation time, first attempt success and subjective difficulty.

No statistically significant differences were observed between the groups in terms of Cormack-Lehane grades and POGO scores used in the evaluation of glottic appearance. However, the fact that the right-hand dominant group had a higher median POGO score and exhibited a lower Cormack-Lehane distribution may reflect a technical advantage in terms of visual field. These findings are consistent with the differences in glottic appearance quality associated with hand dominance reported by Adhikary et al.[5] and Carlson et al.[2] reported that the left-sided laryngoscope blade may provide technical ease in certain anatomical situations, but this method requires habituation, especially for right-hand dominant individuals. This assessment supports the inference that standard equipment may not be sufficiently ergonomic for left-handed individuals in all situations. Especially in 3D motion analyses, dominant hand use has been shown to be more stable and effective in positioning the laryngoscope blade. The tendency toward better glottic visualization observed in right-hand dominant individuals in our study aligns with these findings; however, this difference did not reach statistical significance. Lee et al.[3] reported that laryngoscopy performed with the dominant hand significantly improved glottic visualization. Although our study observed better POGO scores and lower Cormack-Lehane grades in right-hand dominant individuals, this difference may not be statistically significant due to the limited sample size. The same study also evaluated the blade-to-tooth distance and found that this distance was significantly increased during laryngoscopy performed with the dominant hand, meaning that the blade was positioned further away from the teeth. This was interpreted as a factor that increases technical safety, especially in right-hand dominant individuals. However, this parameter was not measured in our study. It is thought that dominant hand-equipment compatibility offers ergonomic advantages that may not only improve procedure success but also reduce the risk of complications. Furthermore, the use of laryngoscopes compatible with the dominant hand may play an important role in preventing dental trauma that may occur during intubation. This topic should be comprehensively investigated in future studies from both anatomical and clinical safety perspectives.

To improve the educational experience for left-handed learners, intubation training programs must be specifically adapted to address the unique challenges faced by these individuals. Given the ergonomic difficulties encountered by left-handed learners when using standard intubation equipment, training programs could benefit from incorporating specific adjustments. For instance, training with equipment that is better suited for left-handed individuals, or providing more tailored feedback during training, may improve both procedural efficiency and comfort. In addition, exploring the feasibility of ambidextrous training, which aims to teach students to proficiently use both hands, is crucial. Studies have shown that performing intubation with the non-dominant hand is technically feasible, although it requires additional practice.[4] Moreover, ElHawary et al.[8] demonstrated that ambidextrous training improves surgical dexterity and technical proficiency, suggesting that such an approach could enhance performance in both hands. Similarly, Skinner et al.[9] examined ambidexterity in laparoscopic surgical training using the Fundamentals of Laparoscopic Surgery (FLS) platform and found that greater ambidexterity was associated with improved overall performance and task proficiency. They suggested that incorporating ambidexterity-focused metrics into training could enhance skill acquisition and retention, highlighting its relevance for procedural skills education in medical curricula. While the applicability of ambidextrous training in intubation remains uncertain, it may offer a potential solution to the difficulties left-handed individuals face with traditional intubation techniques. Incorporating such training into early medical curricula could offer substantial benefits for left-handed learners. Further research is necessary to assess the effectiveness and long-term impact of this training approach within medical education.

In our study, the subjective difficulty level of the intubation procedure was assessed by participants using a Likert scale.[10] Right-hand dominant individuals generally described the procedure as "easy," while left-handed individuals' assessments were more concentrated at the "moderate" and "difficult" levels. Although there was no statistically significant difference between the groups, this trend suggests that left-handed individuals may experience greater cognitive and technical difficulties when working with standard equipment. Similar results have been reported in the literature. Callahan et al.[11] noted that left-handed medical students experienced greater difficulty when working with right-handed equipment. Kuo et al.[4] emphasized that lightwand-guided intubation performed with the non-dominant hand is technically feasible, but this method requires a certain learning process in terms of procedure duration and control. These findings suggest that the relationship between hand dominance and equipment compatibility may affect not only technical success but also mental effort and participants' subjective experiences. In our study, left-handed individuals reporting higher difficulty levels align with these assessments. Baker et al.[12] emphasized that structuring airway training with individualized modules could enhance learning success. Similarly, Aggarwal et al.[13] demonstrated that the use of scenarios tailored to individual differences is effective in simulation-based patient safety training. These findings suggest that educational strategies that take individual differences into account can both improve technical performance and make the learning process more supportive. The mismatch between hand dominance and equipment design may cause left-handed practitioners to perceive the intubation procedure as more complex and challenging during the learning process. This situation may lead to increased subjective difficulty perception, decreased learning motivation, and reduced confidence during the procedure.

In this study, participants were informed that the research aimed to examine the role of hand dominance in intubation performance, which may have unintentionally introduced stereotype threat, particularly for left-handed individuals. Miyake et al.[14] showed that endorsing negative stereotypes, such as the belief that men perform better in physics, can lead to increased anxiety and self-doubt, negatively affecting performance. Similarly, left-handed individuals might have been influenced by the belief that right-handed individuals are superior in tasks like intubation, leading to stereotype threat that could affect both their objective performance and subjective difficulty ratings. Future studies should explore the impact of stereotype threats on left-handed individuals in more detail and consider presenting the study's purpose in a more neutral way or withholding certain information to reduce potential bias and improve the reliability of the results.

Limitations

This study has some limitations. First, the sample size is quite limited. The small number of participants may have prevented the differences observed in some parameters from reaching statistical significance. In addition, all the individuals participating in the study were medical students with no experience in intubation. This means that the data obtained are only valid for beginners and different results may be obtained in more experienced groups. Another limitation is that the study was conducted only in a simulation environment, under fixed conditions, and with a specific mannequin model. While mannequins are useful for standardization, they do not fully replicate the anatomical variability and dynamic physiological responses of real patients. In a clinical setting, factors such as airway shifts, reflexive responses, and patient variability are present, which cannot be accounted for in a simulated environment. Additionally, the mannequin used in this study cannot replicate various patient conditions, such as different airway anatomies or the impact of comorbidities, which could affect intubation performance. These limitations should be considered when interpreting the results. Furthermore, the type of laryngoscope and intubation technique used were kept constant; comparisons using different equipment or alternative techniques could reveal the effect of hand dominance in more detail. In the future, studies with larger samples, participants with different levels of experience, and various equipment and application scenarios will contribute to a more comprehensive assessment of the effect of hand dominance on intubation performance. Finally, the absence of blinding between participants and the researcher may have introduced measurement bias. Knowledge of group allocation and the study hypothesis could have, even unintentionally, influenced the measurement of objective outcomes such as intubation time and success rate. Although these parameters were recorded using standardized procedures, the potential for subtle observer or performance bias cannot be entirely ruled out. We acknowledge that participants' awareness of their hand dominance may have introduced potential bias in the subjective evaluation of the procedure. This awareness may have led left-handed individuals, in particular, to perceive the procedure as more challenging. However, the aim of our study was to reflect real-world conditions, where awareness of hand dominance is common and natural during the training process. Future studies could blind participants to their hand dominance to allow for a more objective assessment of intubation performance.

CONCLUSION

As a result, this study revealed the effects of hand dominance on procedure performance in individuals with no intubation experience and showed that right-hand dominant individuals completed the intubation process in a shorter time. The findings suggest that the ergonomic advantages of standard laryngoscopes being designed for right-hand dominant use have a decisive effect on performance. The low first-attempt success rate and limited glottic view tendency observed in left-handed individuals indicate that equipment incompatibility may negatively affect the learning process. In this regard, considering handedness in intubation training and restructuring training materials to accommodate ergonomic diversity may increase both the effectiveness of the learning process and technical success.

ETHICAL DECLARATIONS

Ethics Committee Approval

For this cross-sectional study permission was obtained from Marmara University Clinical Researches Ethics Committee (Date: 08.12.2023, Decision No: 09.2023.1691).

Informed Consent

All participants signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Innovations in pediatric airway management

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ABSTRACT

Airway management in pediatric patients poses significant challenges due to anatomical and physiological differences from adults. Airway-related complications remain one of the leading causes of morbidity and mortality. In recent years, substantial innovations have emerged in airway management, including advancements in equipment, education, and algorithm-based approaches. Videolaryngoscopes, next generation supraglottic airway devices, airway ultrasonography, and high-fidelity simulations have improved both safety and success in clinical practice. Additionally, updates in international guidelines such as those from the American Society of Anesthesiologists (ASA) and the Difficult Airway Society (DAS) emphasize the importance of algorithmic strategies in practical settings. This review provides a detailed examination of the unique features of pediatric airway anatomy, novel devices and techniques, comparative algorithmic approaches of current guidelines, and future technological developments, supported by the literature.

Keywords: Pediatric airway, videolaryngoscope, supraglottic airway device, airway management, ultrasonography

PEDIATRIC AIRWAY ANATOMY

The anatomy of the pediatric airway differs significantly from that of adults, and these differences directly influence technical approaches and the selection of devices for airway management:[1-3]

Head proportion: Infants have a relatively larger head and a prominent occiput. As a result, when lying in the supine position, their head tends to flex forward, which can easily lead to airway obstruction.

Tongue: The tongue is relatively larger and softer, occupying a substantial portion of the oral cavity. This can cause obstruction during mask ventilation and laryngoscopy.

Nasal passage: The nasal passages are narrow, and even mild edema can lead to significant respiratory distress. Therefore, caution is required when inserting nasogastric tubes or nasopharyngeal airways.

Epiglottis: In young children, the epiglottis is soft, long, narrow, and often omega (Ω)-shaped. It is more difficult to visualize during laryngoscopy and is prone to trauma.

Laryngeal position: The larynx is situated more cranially (at the level of C3-C4) and anteriorly compared to adults. Therefore, the glottic opening is positioned higher when viewed through the oral cavity.

The narrowest segment of the airway: While the glottis is the narrowest point in adults, in children, the narrowest region is the cricoid cartilage (subglottic area). This anatomical difference influences endotracheal tube selection and the choice between cuffed and uncuffed tubes.

Trachea: The trachea is shorter and narrower in diameter; changes in head position can significantly alter the position of the endotracheal tube.

Airway supporting structures: The cartilaginous and soft tissue components of the airway are more pliable and prone to deformation.

A comparative overview of pediatric and adult airway anatomy is presented in Table 1.

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Table 1. Comparison of pediatric and adult airway anatomy

Feature	Pediatric	Adult
Head/occiput	Relatively large	Smaller
Tongue	Relatively large	Smaller
Epiglottis	Soft,long, omega-shaped	Short, firm, flat
Laryngeal position	At C3–C4 level, anterior	At C5–C6 level
Narrowest point	Cricoid cartilage	Glottis
Tracheal length	Short	Long

AIRWAY EQUIPMENT

For safe airway management in pediatric patients, it is essential to have a complete set of basic equipment in various sizes and designs tailored to this population:[2,4]

Face masks: Anatomically shaped silicone masks in a range of sizes specific to neonatology and pediatrics are used. During ventilation, the mask should be appropriately sized to completely cover both the nose and mouth.

Oropharyngeal airway: Used to maintain mouth opening and airway patency in unconscious children or those with reduced muscle tone. Improper sizing-either too large or too small-increases the risk of airway obstruction.

Nasopharyngeal airway: Indicated when oral access is not feasible or contraindicated (e.g., intraoral trauma, tetanus, trismus). However, it is contraindicated in cases of basilar skull fracture or coagulopathy.

Endotracheal tubes (cuffed/uncuffed): In most pediatric cases, cuffed tubes are preferred. Tube diameter and length are calculated based on age and weight; selecting the appropriate size is critical to prevent subglottic injury.

Laryngoscopes: Both Miller (straight) and macintosh (curved) blades in various sizes can be used in pediatric patients. Miller blades are particularly advantageous in neonates and infants.

ADJUNCT DEVICES FOR DIFFICULT AIRWAY MANAGEMENT

In the management of difficult airways, various adjunct devices and techniques play a crucial role in clinical practice alongside standard equipment:[1,5]

Videolaryngoscopes: Provide a wide and clear glottic view without the need for direct line-of-sight visualization. Pediatric-sized blades and accessories enhance success rates in challenging cases.

Fiberoptic bronchoscope: Considered the gold standard in cases involving anatomical anomalies, trismus, or cervical immobilization. Pediatric models with smaller diameters have been developed for safe use.

Bougie: Useful when the vocal cords are not visible but access to the trachea is desired. Pediatric-sized bougies are also available.

Stylets and introducers: Facilitate modification of the tube shape and aid in navigating an anteriorly positioned larynx.

Supraglottic airway devices (SGAs): Provide rapid and reliable oxygenation, particularly when both mask ventilation and endotracheal intubation have failed.

FONA TECHNIQUES (FRONT OF NECK AIRWAY)

FONA is an abbreviation for “front of neck access” and refers to emergency airway access procedures performed in situations where oxygenation cannot be achieved, known as “can't intubate, can't oxygenate (CICO)” scenarios.[8,9] FONA techniques differ between adult and pediatric patients.

FONA Techniques in Adults

Surgical cricothyrotomy: Incision of the cricothyroid membrane using a scalpel followed by tracheal cannulation.
Needle cricothyrotomy: Penetration of the membrane with a large-bore needle and administration of jet ventilation.

Specific Considerations for FONA in Pediatric Patients

Anatomical challenges: In pediatric patients, the cricothyroid membrane is extremely thin and narrow; identification and application are particularly difficult in children under 8 years of age.[4]

Risk of complications: Due to the smaller size of tracheal and laryngeal structures and the softness of the cartilages, the risk of significant injury, bleeding, and subglottic stenosis from incorrect procedures is higher compared to adults.

Needle cricothyrotomy: Involves puncturing the membrane with a 14-18G needle and providing oxygen. However, carbon dioxide retention and barotrauma may develop rapidly; therefore, a definitive surgical airway should be established as soon as possible.

Guideline recommendations: Current guidelines such as those from the ASA and DAS do not recommend surgical cricothyrotomy in children under 8 years of age. In emergency situations, needle cricothyrotomy (with jet ventilation) is considered the only recommended technique.[8,9]

The main characteristics of pediatric front-of-neck access (FONA) techniques are presented in Table 2.

Table 2. Characteristics of pediatric FONA techniques

Age Group	Recommended FONA technique	Notes
≤ 8 years	Needle cricothyrotomy + jet oxygenation	Surgical cricothyrotomy is not recommended.
≥ 8 years	Needle or surgical cricothyrotomy	Anatomical feasibility is essential.

Clinical practice: The application of FONA in pediatric airway management should be performed only by well-trained teams, with appropriate indications and prompt decision-making.

ADVANCES IN PEDIATRIC AIRWAY MANAGEMENT: EQUIPMENT AND APPLICATIONS

Videolaryngoscopes[1,5,6,7]

Videolaryngoscopy (VL) has emerged as a technique that can significantly increase intubation success, particularly in difficult airway scenarios and emergency intubations. Recent systematic reviews and meta-analyses demonstrate that VL offers higher success rates compared to direct laryngoscopy, with this advantage being especially prominent in difficult cases.[5] However, the available clinical evidence in the pediatric population remains limited, and the superiority of VL has not been clearly established; there is a recognized need for further randomized controlled trials in this area.[6]

Advanced-generation videolaryngoscopes such as the Glidescope can enhance operator comfort by reducing both subjective and objective cognitive load. This feature provides a significant advantage, particularly for less experienced users.[7] Nevertheless, in certain cases, direct laryngoscopy may be performed more rapidly and may yield similar or even shorter times to first-attempt intubation compared to VL. Therefore, in emergency situations, both the level of preparation and operator experience are critical determinants.

From an educational standpoint, videolaryngoscopes serve as valuable tools for both specialists and trainees by enabling direct visualization of airway anatomy and facilitating the teaching of correct intubation techniques. A comparative overview of the benefits and limitations of VL is provided in Table 3.

Table 3. Advantages and disadvantages of videolaryngoscopy

Advantages	Disadvantages
Risk of esophageal intubation ↓	Impaired view due to oropharyngeal secretions, blood, gastric contents, or fogging
Good glottic visualization	Efficacy may vary among different VL devices
Easy to learn and teach	Not 100% success rate
Does not require alignment of the oral–pharyngeal–laryngeal axis	Expensive and not available in all hospitals
Allows easy identification of edema and other pathological changes	Depth perception may be compromised due to two-dimensional view
Need for neck manipulation ↓	May result in inadequate preparation for difficult airway scenarios
Ergonomic for the user	
Confidence in both user and device ↑	

Considerations for the Use of Videolaryngoscopes

- The selected videolaryngoscope must be appropriate in terms of blade size and type.
- Application of different techniques may be required depending on the clinical scenario.
- A stylet and lubricating agent should be used with the endotracheal tube.
- The endotracheal tube should be shaped to match the angle of the blade.
- Proper hand–eye coordination is essential for successful intubation.

Limitations of Videolaryngoscope Use

- Inadequate mouth opening
- Fogging of the lens
- Presence of secretions
- Bleeding in the airway
- Technical malfunctions or equipment failure

Fiberoptic Bronchoscope[10]

- Fiberoptic bronchoscopy (FOB) is considered the "gold standard" intubation technique in pediatric cases with anatomical variations, airway tumors, syndromic conditions, cervical spine immobilization, or limited mouth opening.
- With advancing technology, ultra-thin fiberoptic bronchoscopes suitable for use in neonates and infants have been introduced into clinical practice.
- FOB can be performed via the oral or nasal route, or through a supraglottic airway device.
- It is preferred in cases involving anatomical abnormalities, airway tumors, or anticipated difficult intubations.

A detailed summary of the procedural steps for performing FOB is provided in Table 4.

Table 4. Fiberoptic bronchoscopy: procedural steps and clinical considerations

Step	Application	Clinical notes
Preparation	The anesthesiologist is positioned at the head of the patient; an appropriately sized pediatric bronchoscope is selected	Pediatric bronchoscopes typically range from 2.2 to 3.5 mm in diameter
Lubrication	The distal tip of the bronchoscope is lubricated with a suitable gel	Minimizes mucosal trauma
Tube Preparation	The endotracheal tube (ETT) is preloaded onto the bronchoscope	The ETT internal diameter should match the bronchoscope size
Advancement	The bronchoscope is advanced via the oral or nasal route, directed beneath the epiglottis	Nasal route is more physiological but carries higher risk of edema
Visualization	The vocal cords are visualized clearly	Aspiration of secretions or blood may be required for optimal view
Intubation	The ETT is advanced through the vocal cords into the trachea	Slow and controlled advancement is essential in pediatric patients

Next-Generation SGA Devices[11-13]

Next-generation supraglottic airway (SGA) devices, such as the I-gel and LMA Supreme, have been increasingly adopted in pediatric anesthesia due to their design innovations. These devices offer several advantages, including the presence of a gastric drainage channel and ease of insertion, which contribute to reduced risk of aspiration and improved airway seal. The I-gel, constructed from a gel-like thermoplastic elastomer, provides a non-inflatable cuff that adapts to the perilaryngeal anatomy, facilitating rapid and atraumatic placement. Similarly, the LMA Supreme incorporates both a gastric channel and an anatomically curved airway tube, supporting safe and effective use during both elective and emergency airway management in children (Table 5).

Table 5. Next-generation supraglottic airway (SGA) devices

Device	Characteristics	Advantages	Limitations
I-gel	Non-inflatable, gel-like cuff design	Rapid placement, low trauma, allows fiberoptic intubation guidance	Limited evidence in smaller pediatric sizes
LMA supreme	Equipped with a gastric drainage channel	Reduced aspiration risk, reliable in emergency settings	Higher cost
LMA proSeal	Dual lumen, higher seal pressure	Better oropharyngeal seal, safe for prolonged use	Placement may be more difficult
Ambu AuraGain	Anatomically curved design with a channel for fiberoptic intubation	Facilitates guided intubation	Requires operator experience

Airway Ultrasonography[14,15]

Ultrasonography (USG) has emerged as a reliable, noninvasive, and bedside-applicable method in the evaluation of the pediatric airway (Table 6).

USG enables direct measurement of airway diameter, tracheal rings, and the glottic level, offering high accuracy in determining appropriate endotracheal tube size, particularly in patients with anatomical variations.[14]

Selecting an endotracheal tube of appropriate size and preventing complications such as subglottic injury and ventilation failure are critically important, especially in pediatric patients.[15]

Subglottic diameter measurement: Assists in determining the appropriate endotracheal tube size.

Verification of tube placement: Ultrasonography can be used to confirm correct endotracheal tube positioning and to visualize tracheal structures and the cricothyroid membrane.

Localization of the cricothyroid membrane: Provides a reliable anatomical landmark for emergency airway access.

Table 6. Clinical applications of pediatric airway ultrasonography

Application	Description	Clinical advantage
Subglottic diameter measurement	Used to determine appropriate endotracheal tube size	Improves tube selection, prevents subglottic injury
Verification of intubation	Confirms correct tracheal placement of the tube	Reduces risk of post-extubation complications
Cricothyroid membrane localization	Identifies anatomical landmarks for emergency airway access	Particularly useful in obese or edematous children
Tracheal ring assessment	Evaluates tracheal anatomy in congenital anomalies	Enables personalized airway planning

SIMULATION AND TRAINING[16-18]

Recently, machine learning-based models that incorporate demographic data such as age, height, weight, and other parameters have been reported to outperform classical age-diameter formulas in predicting appropriate endotracheal tube size.[16] Traditional formulas, such as the Cole formula ([Age/4]+4), have long been used to estimate the appropriate endotracheal tube size in pediatric patients. Although these formulas provide a simple and practical approach in clinical practice, they do not adequately account for inter-individual anatomical variations, such as differences in subglottic diameter, tracheal length, or airway compliance. Consequently, the exclusive reliance on such formulas may increase the risk of selecting an inappropriate tube size, potentially leading to complications including subglottic injury, air leak, or inadequate ventilation. In contrast, imaging-based modalities such as airway ultrasonography, together with artificial intelligence–supported clinical decision support systems, offer a more individualized and precise method by integrating real-time anatomical measurements and demographic data. These technologies therefore have the potential to mitigate the limitations of traditional formulas and enhance both the accuracy and safety of pediatric airway management. Examples of artificial intelligence applications in pediatric airway management are outlined in Table 7.

In the future, integrating machine learning algorithms into clinical decision support systems may allow for personalized and safer airway management in pediatric intensive care and anesthetic practice.

Clinical Benefits

- Faster and safer airway access
- Personalized tube size selection
- Early prediction of difficult airway risk

Table 7. Examples of artificial intelligence integration

Image processing algorithms for estimating subglottic diameter (ultrasound-based)
Risk stratification systems that predict intubation difficulty using preoperative data
Real-time clinical decision support systems (e.g., guidance during videolaryngoscopy)
Digital assistants powered by machine learning that recommend tube size (based on height, weight, age, and gender for appropriate tube diameter prediction)

Airway Management in Pediatrics[1,19]

Pediatric airway management requires a much more meticulous evaluation and preparation process compared to adults due to the unique anatomical and physiological characteristics of children (Table 8). Ensuring a safe airway during the perioperative period necessitates comprehensive preoperative assessment, appropriate equipment selection, recognition of human factors (Table 9), and the integration of effective algorithmic approaches in emergency situations (Table 10). In this context, intra-team communication and multidisciplinary collaboration play a critical role throughout all stages of airway management. Additionally, because airway complications in children can develop rapidly, the entire airway plan should be shared with the team, and alternative strategies should be readily available.

Table 8. Airway management in pediatrics

Stage	Details
Preoperative evaluation	- Medical history and physical examination - Anatomical features may contribute to intubation difficulty - A multidisciplinary approach may be required - Airway plan should be shared with the team
Preoxygenation	- Mask ventilation may be difficult (due to lack of cooperation in children) - Oxygen delivery ensures an oxygen reserve for safe apnea duration
Anesthesia induction	- Adequate anesthesia/sedation must be ensured - Neuromuscular blockade (NMB) should be administered if necessary - Awake intubation may be preferred in selected cases
Apneic oxygenation	- Continuous oxygen flow maintains an open airway - Creates reservoir in the nasopharynx and trachea - Increases intubation success - Prolongs the duration of apnea
Airway management	- Videolaryngoscopy is recommended in infants and neonates - A hyperangulated videolaryngoscope blade may be considered in difficult airways - Alternative airway strategies should be prepared
Extubation	- Not an emergency; safety takes priority - A reintubation plan must be available - Post-extubation complications should be anticipated - Proper equipment and experience are essential

Table 9. Human factors

Component	Explanation
Cognitive aids	Checklists, color-coded medications, and emergency algorithms reduce the rate of error.
Communication	Communication should be bidirectional (closed-loop communication is preferred).
Team communication	Team members should be able to openly express their concerns.
Post-event evaluation	Unsuccessful interventions should be analyzed; strengths and areas for improvement should be identified.

Table 10. Can't intubate, can't oxygenate (CICO) scenario

Age group	Recommended approach
<1 year	Surgical cricothyrotomy is not recommended.
1-8 years	Modified needle cricothyrotomy and use of a tracheal tube are recommended.
≥8 years	Surgical cricothyrotomy may be performed at the level of the 2nd or 3rd tracheal ring.

ALGORITHMIC APPROACH: ASA AND DAS PEDIATRIC DIFFICULT AIRWAY ALGORITHMS[8,9]

ASA (American Society of Anesthesiologists) Pediatric Difficult Airway Algorithm[8]

In the 2022 ASA guidelines, while the adult algorithm serves as the foundation for pediatric patients, several important modifications and cautions have been introduced to accommodate age-related and anatomical differences specific to children (Table 11).

Table 11. ASA pediatric difficult airway algorithm

Step	Method/strategy	Explanation
Preparation	Prepare equipment and alternative plans	Risk assessment, monitoring
Intubation attempts	Intubation with direct or videolaryngoscope	Maximum of 2 attempts; oxygenation after each attempt
Alternative airway	Supraglottic airway device (SGA)	Fiberoptic intubation if necessary
	Mask ventilation	Two-person technique, airway adjuncts, patient positioning
Emergency surgical airway	Surgical airway	Jet ventilation, needle cricothyrotomy

The guideline is structured under the following main headings: preparation, planned intubation, alternative strategies, and emergency surgical airway.

Preparation and Assessment

- In all cases, the risk of difficult airway should be evaluated through detailed medical history and physical examination.
- If there is suspicion: An awake or sedated approach is recommended, and transfer to a tertiary care center should be considered if feasible. Awake intubation or elective invasive airway is preferred.
- Equipment (videolaryngoscope, fiberoptic bronchoscope, SGA, FONA tools), medications (including emergency drugs) must be readily available.
- A multidisciplinary team and communication strategy should be established; roles should be defined in advance.

Intubation Attempts

- Intubation should be attempted using direct or VL; a maximum of two attempts is recommended.
- Oxygenation should be ensured after each attempt; in case of failure, the next step should be initiated without delay.

Alternative Strategies

SGA, fiberoptic intubation

- If intubation fails, a supraglottic airway device (SGA, e.g., i-gel, LMA) should be used to attempt oxygenation.
- Fiberoptic intubation through the SGA can be attempted if necessary.

Mask ventilation

- If mask ventilation fails, two-person technique, airway adjuncts, and optimal patient positioning should be applied.
- Preoxygenation and maintenance of ventilation are essential at this stage.
- If unsuccessful or if ventilation deteriorates, transition to the emergency airway algorithm is indicated.
- If marginal:

- Anatomical or functional obstruction should be excluded or treated.

- If necessary, assistance should be called for invasive airway access or ECMO.
- If impossible (severe hypoxemia):
- Emergency airway management should be initiated.
- If intubation and ventilation cannot be achieved, emergency invasive airway access (e.g., surgical airway) is mandatory.

FONA (Front of Neck Airway) / Emergency Surgical Airway

- If a CICO situation arises, age-appropriate FONA techniques should be applied:
  - o <1 year: Surgical cricothyrotomy is not recommended.
  - o 1-8 years: Modified needle cricothyrotomy and use of small-diameter tracheal tube are recommended.
  - o >8 years: Surgical cricothyrotomy can be performed at the appropriate tracheal level.

Critical Points

Throughout the algorithm, continuous optimization of oxygenation and maintenance of adequate anesthetic depth are essential.

Awareness of time between intubation attempts is crucial; unnecessary attempts should be avoided.

Assistance may be summoned at any stage.

Outcome

If oxygenation and ventilation are successfully maintained, the procedure can proceed.

✓ Effective implementation of preoxygenation and apneic oxygenation is of critical importance in pediatric patients.

✓ Team communication should be ensured after each step, and the continuity of oxygenation must be maintained.

✓ All interventions should be performed using age-and weight-appropriate, pediatric-sized equipment.

DAS (DIFFICULT AIRWAY SOCIETY) PEDIATRIC DIFFICULT AIRWAY ALGORITHM[9]

The 2015 DAS guideline and subsequent updates propose a systematic and practical pediatric difficult airway algorithm, distinct from the adult version.

The main goals are the maintenance of oxygenation and rapid transition between sequential steps (Table 12).

Preparation

- An experienced anesthesiologist and a team skilled in airway management should be present and ready.
- All necessary equipment (videolaryngoscope, fiberoptic bronchoscope, SGA, bougie, FONA devices) must be readily available.
- Role allocation within the team should be defined in advance.

Table 12. DAS pediatric difficult airway algorithm

Step	Method/strategy	Explanation
Preparation	Experienced team, monitoring, equipment	
Intubation attempt	Direct or video laryngoscopy	Max. 2 attempts
Failed intubation	Oxygenation via face mask	Two-person technique, airway adjuncts
Failed mask ventilation	Supraglottic airway (SGA)	If oxygenation is achieved, proceed with the intervention
SGA failure / no oxygenation	Emergency surgical airway (needle cricothyrotomy, jet ventilation)	Last resort; surgical approach not recommended under 8 years of age

Intubation Attempt

- Intubation should be attempted using direct or VL; no more than two attempts are recommended.
- If oxygenation is lost or intubation fails, the next step should be initiated immediately.

Mask Oxygenation

- If mask ventilation is unsuccessful, adjunct airway devices, two-person technique, and optimal positioning should be employed.
- If oxygenation can be maintained, the procedure can safely continue.

SGA Placement

- If mask ventilation is not feasible, a supraglottic airway (SGA) device should be inserted immediately.
- If oxygenation is achieved via the SGA, fiberoptic intubation through the device can be attempted if necessary.

FONA (Front of Neck Airway) / Emergency Surgical Airway

- If oxygenation cannot be achieved with SGA, emergency surgical airway (FONA) should be considered.
  - o ≤8 years: Surgical cricothyrotomy is not recommended; needle cricothyrotomy with jet ventilation is preferred.
  - o ≥8 years: Either surgical or needle cricothyrotomy may be performed.

✓ Maintenance of oxygenation is essential at every stage.

✓ In the event of a failed intervention, the next step should be initiated without delay.

✓ Patient safety must be prioritized throughout all phases.

KEY CLINICAL HIGHLIGHTS FROM GUIDELINES

- In pediatric difficult airway algorithms, age, body weight, and compatibility with available equipment are critically important factors.
- The primary goal emphasized in both algorithms is: Ensuring continuous oxygenation and effective airway management without the development of complications.

- At each stage, team communication, cognitive aids (e.g., checklists, color-coded medications), and crisis management should be prioritized.

CONCLUSION

Pediatric airway management is a complex and high-risk process due to unique anatomical and physiological differences, rapid decompensation risk, and evolving equipment and techniques. Contemporary guidelines (ASA, DAS), with their algorithmic approaches and device diversity, enhance applicability in clinical practice. VL, new-generation SGAs, ultrasonography, and simulation-based training have become indispensable components of clinical success supported by experience and up-to-date education. The integration of regularly updated guidelines and technologies enables safe and effective pediatric airway management, leading to improved outcomes.

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The authors have no conflicts of interest to declare.

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All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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A case report of quetiapine intoxication in our intensive care unit and literature review

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ABSTRACT

Quetiapine is one of the atypical antipsychotic drugs that is widely used, especially in psychiatric practice. There are case reports of quetiapine overdose in the literature. In this article, we present the case of intensive care management of an adult male patient after high-dose quetiapine intake with the help of the current literature. A systematic literature review was conducted along with the case report. The PubMed, Web of Science, and Scopus databases were searched for "quetiapine intoxication," yielding 25 articles. Of the twenty-one quetiapine overdose articles, 1963 cases were identified. The mean age of the cases was 34.5 years, and the cases were predominantly female. The patients were more likely to have a diagnosis of depression. The mean dose was calculated to be 9.6 g. The most common neurological findings were coma and accompanying seizures. Cardiovascular (CVS) findings included tachycardia, hypotension, and QTc prolongation. Since quetiapine does not have an active antidote, activated charcoal and gastric lavage are typically administered to patients after they present to the emergency department. Intubation was required in severe cases. Mortality was 31 in 1693 cases (1%). Three patients used alcohol together with quetiapine. Rhabdomyolysis developed in 14 patients. Neuroleptic malignant syndrome (NMS) developed in 2 patients, and acute respiratory distress syndrome (ARDS) due to quetiapine use in 1 patient. In a case report, carboxyhemoglobin (COHb) elevation was detected as a result of the use of quetiapine together with zolpidem. In cases of quetiapine intoxication, patients should be monitored in the ICU due to the development of life-threatening conditions, including neurological, CVS, and renal system effects of the drug. There is no specific antidote. Therefore, patients may need supportive treatments. This study was associated with significant toxicity and dangerous complications in quetiapine overdose. In more severe overdose cases, careful and often prolonged clinical observation is required.

Keywords: Quetiapine intoxication, intensive care unit, suicide

INTRODUCTION

Quetiapine is a frequently prescribed antipsychotic and is therefore frequently overdosed. The clinical picture is characterized by a variable combination of peripheral and central symptoms, with agitation frequently occurring.[1]

Quetiapine interacts as an antagonist with a wide range of neurotransmitter receptors in the brain. It has been proposed that its antipsychotic activity is mediated through a combination of dopamine type 2 (D2) and serotonin type 2 (5-HT2) antagonism. It also has high affinity for α1-adrenergic and histamine receptors, but lower affinity for muscarinic receptors. However, as with other antipsychotic drugs, the exact mechanism of action of quetiapine is still unknown. The average therapeutic dose concentration is 0.4 mg/L; a dose of 200-750 mg per day can be administered. The pharmacologic effect of the drug causes the signs and symptoms of overdose. Antagonism of histamine H1 receptors causes sedation and somnolence. Orthostatic dysregulation, hypotension, and tachycardia are due to an antagonistic effect on α1-adrenergic receptors. Quetiapine also causes anticholinergic-mediated tachycardia due to an antagonistic effect on M1-muscarinic receptors. Overdose also causes QTc (cardiac QT interval, when the standard heart rate is 60/minute) prolongation, respiratory depression, status epilepticus, rhabdomyolysis, confusion, coma, and death.[2]

The elimination half-lives of quetiapine and its active metabolite, norquetiapine, are approximately 7 and 12 hours, respectively. In the event of an acute overdose, standard precautions include airway protection, adequate oxygenation, and ventilation.[3]

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Quetiapine has no known antidote. Treatment of intoxication is mainly supportive. Physostigmine is described as a specific treatment for anticholinergic delirium/toxidrome. The efficacy of other pharmacologic interventions remains unclear.[1]

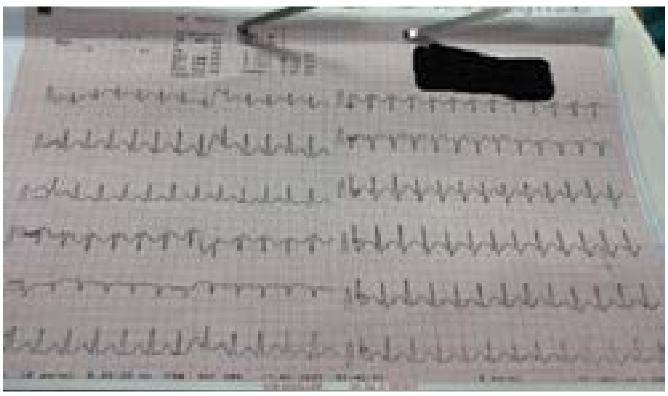
The case we present here only involves the intensive care follow-up and treatment of a patient who developed elevated COHb after an overdose of quetiapine. When we look at the literature, patients with elevated COHb have taken other medications along with quetiapine. However, in our case, elevated COHb was detected only after the use of quetiapine was initiated.

METHODS

A systematic literature review was conducted along with the case report. The PubMed, Web of Science, and Scopus databases were searched for "quetiapine intoxication," yielding 25 articles.

CASE REPORT

A 42-year-old male patient was brought to the emergency department (ED) by his relatives in a state of sleepiness. According to the anamnesis taken from the patient, it was learned that he had taken 20 quetiapine 200 mg for suicidal purposes within approximately 1 hour. The patient's Glasgow Coma Scale (GCS) score was 11 at the time of presentation to the ED and subsequently decreased to 8, at which point the patient was intubated in the ED. During the ED follow-up, the patient's GCS decreased to 8, and his breathing pattern deteriorated. His breathing became superficial, and his respiratory rate gradually decreased. For this reason, the patient was intubated by the ED physician due to the development of respiratory acidosis in the arterial blood gas. ECG performed in the ED showed a heart rate of 155 beats/min, QTc 514 ms (prolonged) (**Figure 1**),blood pressure of 140/78 mmHg, SpO_2 of 99%, and urine output of 100 cc/h. In the ED, after gastric lavage was performed, 8-10 pieces of drug residue were detected along with food residues.



Therefore, activated charcoal administration was performed by nasogastric gastric lavage. We will talk about our management in our intensive care unit after the patient, who was followed up with a diagnosis of depression and had no other comorbidities, took 20 quetiapine 200 mg (4 gr) for suicidal purposes.

The patient was intubated in the ED and then transferred to our intensive care unit. The patient's general condition was poor, with a closed consciousness and a GCS of 3. After the patient was intubated in the emergency room, he was quickly transferred to the intensive care unit. During the neurological examination performed in the intensive care unit, the GCS was determined to be 3. Although the reason for the low GCS was attributed to the sedative and neuromuscular blocking drugs administered during intubation, the progressive decrease in the GCS of the ED patient prevented us from making a clear distinction. The patient was connected to a mechanical ventilator, with the following settings: PEEP 5 cmH_2O, FiO_2 50%, and tidal volume 500 ml in SIMV mode. Upon admission to the intensive care unit, the heart rate was 120 beats/min, the blood pressure was 140/85 mmHg, the SpO_2 was 99%, and the respiratory sounds were normal bilaterally. The abdomen was relaxed, and urine output was 100 cc/h. Laboratory values of the patient before emergency room admission, ICU admission, and ICU discharge are given in **Table 1**.

Table 1. Laboratory values of the patient

	Emergency room admission	ICU admission	ICU output
Glucose mg/dl	113	108	107
Urea mg/dl	11	11	21
Creatinine mg/dl	0.96	0.93	1.15
SGPT U/L	11	12	12
SGOT U/L	18	20	16
LDH U/L	118	208	-
GGT U/L	18	17	-
Creatine kinase (CK) U/L	18	-	-
C-reactive protein (CRP) g/L	0.8	0.8	12.8
Sodium mmol/L	139	139	144
Potassium mmol/L	3.3	3.8	4,5
Chlorine mmol/L	102	103	105
GFR ml/min/1, $73m^2$	96	100	78
White blood cell $x10^9/L$	8.4	6.3	12.8
Hemoglobing/dl	15.8	14.8	14.1
Platelet $x10^9/L$	187	184	167
Troponin ng/L	4	-	-
PH	7.32	7.45	7.39
PCO_2 mmHg	45	28	50
PO_2 mmHg	96	23	46
BE mmol/L	2.9	2.5	4.4
HCO_3 mEq/L	23	19	30
Lactate mg/dl	42	44	14
COHb %	13	8.3	1.8
APTT sec	20	26	-
PTT sec	14	15	14
INR	1.03	1.1	1.06

ICU: Intensive care unit, SGPT: Serum glutamic-pyruvic transaminase, SGOT: Serum glutamic-oxaloacetic transaminase, LDH: Lactate dehydrogenase, GGT: Gamma-glutamyl transferase GFR; Glomerular filtration rate, BE: Base excess, APTT: Active partial thromboplastin time, PTT: Prothrombine time

Since quetiapine has no known antidote, supportive treatment was provided in our intensive care unit. The patient was hydrated with 100 cc/h of balanced fluid; sedative drugs were not used. Ulcer and deep vein thrombosis prophylaxis was applied. The patient regained consciousness and started breathing spontaneously on the 20th hour of his admission to our intensive care unit, and was extubated in a controlled manner. No cardiac or hepatic complications were observed during the patient's follow-up. He also did not require dialysis. The patient, who had no problems during follow-up after extubation, was transferred to the psychiatric service with recommendations.

LITERATURE REVIEW

Pubmed, Web of Science, and Scopus databases were searched to identify cases of quetiapine intoxication. Twenty-three articles were found by searching ''quetiapine intoxication''. The terms "case report" or "case series" were used. A comprehensive search of the relevant literature was conducted, including letters to the editor and review articles.

One thousand nine hundred sixty-three cases were identified from 21 quetiapine overdose articles. The characteristics of these cases are summarized in **Table 1**. The mean age of the cases was 34.5 years, and the cases were predominantly female. Patients were primarily diagnosed with depression. The mean dose was approximately 9.6 g. The most common neurologic finding was coma and accompanying seizure. CVS findings included tachycardia, hypotension, and QTc prolongation. Quetiapine was not administered because it lacks an active antidote. Supportive treatment/drug excretion-enhancing interventions were performed. Activated charcoal and gastric lavage were mainly administered after admission to the ED. Intubation was needed in severe cases. Mortality was 31 out of 1693 cases (1%). Three patients used alcohol with quetiapine. Fourteen patients developed rhabdomyolysis. 2 patients developed NMS, and one patient developed ARDS due to quetiapine use.

When we reviewed the literature, the case report by Quinn et al. (2009) found elevated COHb as a result of quetiapine use with zolpidem. In the case report by Ninčević et al. (2017), liver function tests and CK values were found to be elevated. In the follow-up of this patient, rhabdomyolysis, NMS, and the need for hemodialysis developed. In a case series by Dobravc et al./2024, hypopotassemia was found in 17 patients and acidosis in 19 patients. Hypopotassemia was also reported in a case study by Gajwani et al. (2000). Elevated CK was found in a case report by Müller et al. [2-22] in 2010 (**Table 2, 3**).

Table 2. Patient demographics and clinical presentation

Article/year	Number of cases	Age	Sex	Diagnosis	Dose	Neurological
Bertol et al. v. 2021[2]	1	75	Male	Depression/ bipolar	28 g	Coma
Caterina et al./2022[3]	1	64	Female	Depression	Unknown	Coma
Cetin et al. 2011[4]	1	21	Female	Depression	18 g	Coma-Seizure
Quinn et al/2009[5]	1	57	Female	Unspecified	Unspecified Coma	
Harmon et al/1998[6]	1	26	Female	Unspecified	10 g	Coma
Hunfeld et al/2006[7]	14	Unspecified	Unspecified		1.2-18 g	Coma
Jiaoyang et al./2025[8]	1	26	Male	Depression	500 mg	Coma
Peridy et al. /2019[9]	372	Unspecified	Unspecified		1500 mg and above	Coma
Ninčević et al. v. 2017[10]	1	32	Male	Bipolar	24 g	Coma
Dobravc et al. v./2024[11]	134	32.5 (average)	42% Male	Unspecified	10 g (average)	Coma-Seizure
Corrine et al/2003[12]	18	31 (average)	34% Male	Unspecified	3.5 g (average)	511 Seizure
Hustey /1999[13]	1	19	Male	Schizophrenia depression	9.6 g	Coma
Gajwani et al. 2000[14]	1	19	Male	Schizophrenia depression	10 g	Coma
Adelina et al/2008[15]	945	35 (average)	Unspecified		Unspecified	10% Coma
Precourt et al/2005[16]	1	53	Male	Unknown		Unspecified Coma-Seizure
Pfab et al. 2011[17]	20	Unspecified	15% Male	Unspecified	9.8 g (average)	100% Coma 20% Seizure
Isbister et al/2009[18]	176		Unspecified	Unspecified	Unspecified 48% Coma	
Fernandes et al/2002[19]	1	52	Male	Schizophrenia	10.800 mg	Coma
Strachan et al.2012[20]	1	41	Male	Bipolar	4500 mg	Coma
Mattoo et al/2009[21]	1	23	Female	Schizophrenia depression	1400 mg	Sommolance
Müller et al.2010[22]	1	32	Female	Unspecified	36 g	Coma

Table 3. Patient clinical presentation

Article/year	Intubated	Cardiological	Lavage/coal	Mortal	Feature
Bertol et al. v. 2021[2]	Yes	QTc prolongation	Yes	Yes	CPR
Caterina et al./2022[3]	Yes	Unspecified	Unspecified	No	Hemadsorption
Cetin et al. 2011[4]	Yes	Tachycardia	Yes	No	Concomitant use with alcohol
Quinn et al/2009[5]	Yes	Unspecified	Unspecified	No	Concomitant use with alcohol and zolpidem- COHb elevated
Harmon et al/1998[6]	Yes	Tachycardia	Unspecified	No	Unspecified
Hunfeld et al/2006[7] Jiaoyang et al./2025[8] Peridy et al. /2019[9] Ninčević et al. v. 2017[10]	Yes Yes Yes	Unspecified tachycardia No Tachycardia Tachycardia	Unspecified Yes Unspecified Yes	No No 0.13% ex No	Unspecified acute kidney injury Rhabdomyolysis hemodialysis Unspecified Concomitant use with alcohol - NMS -Rhabdomyolysis hemodialysis
Dobravc et al. v./2024[11]	72% Yes	93% tachycardia	Yes	12% ex	Rhabdomyolysis
Corrine et al/2003[12]	22% Yes	55% QTc prolongation	Unspecified	No	Unspecified
Hustey /1999[13]	Yes	Tachycardia	Yes	No	Unspecified
Gajwani et al. 2000[14]	Yes	Tachycardia QTc prolongation	Unspecified	No	Unspecified
Adelina et al/2008[15]	5% Yes	56% tachycardia	Unspecified	0.03%	Unspecified
Precourt et al/2005(16)	Yes	QTc prolongation	Yes	No	Venlafaxine Concomitant use NMS
Pfab et al. 2011 [17]	70% Yes	60% tachycardia 65% QTc prolongation	Unspecified	5% mortal	Unspecified
Isbister et al/2009[18]	Unspecified	67% tachycardia	Unspecified	Unspecified	Unspecified
Fernandes et al/2002[19]	Yes	Hypotension	No	Yes	CPR
Strachan et al. 2012[20]	Yes	QTc prolongation	Unspecified	Unspecified	ARDS
Mattoo et al/2009[21]	No	Tachycardia	Yes	No	Unspecified
Müller et al. 2010[22]	Yes	Tachycardia	Yes	No	Unspecified

DISCUSSION

In this case, we describe the management of a 42-year-old male patient in our intensive care unit after he took 20 200 mg (4 g) quetiapine for suicidal purposes. Our patient was intubated in our ICU after a coma due to quetiapine intoxication. When the laboratory parameters of our patient were evaluated, respiratory acidosis, hypopotassemia, and elevated COHb were detected on admission to the ICU. Renal function tests, liver function tests, and CK value were found to be normal at the time of admission to AS and during discharge from the ward.

In a case report by Quinn et al.[5] in 2009, a 57-year-old female patient had used quetiapine along with zolpidem, oxycodone, citalopram, and alcohol for suicidal purposes. As a result, elevated COHb was found. In our case, COHb elevation was also observed due to the isolated use of quetiapine. In quetiapine intoxication, care should be taken in terms of COHb elevation and findings of carbon monoxide intoxication.

In a case report by Caterina et al.[3] in 2022, a patient who developed coma after quetiapine overdose was successfully treated by using hemadsorption. Since quetiapine has no known antidote, this method was used as a treatment option.

The systems most commonly affected by quetiapine overdose are the neurologic and CVS systems. In many patients, coma and seizure have been reported due to unconsciousness.

Hypotension, tachycardia, and QTc prolongation as CVS side effects occurred in many patients. Since these effects were life-threatening, patients needed supportive treatment (CPR, intubation, vasopressor use, hemodialysis, etc.) in intensive care units.[2-22]

In the literature, patients who developed acute kidney injury, rhabdomyolysis, and NMS in some patients due to overdose of quetiapine have been mentioned. In some of these patients, hemodialysis was used for treatment. Care should be taken in terms of renal damage, rhabdomyolysis, and NMS in quetiapine intoxication.[8,10,11,16] We did not observe these conditions.

Strachan et al.[20] reported that ARDS developed in a 41-year-old male patient in a case report in 2012.

Some cases of a mortal course of overdose of quetiapine have also been reported.[2,9,11,15,17,19] Quetiapine has been on the market for twenty-five years. It is encountered more frequently in autopsies due to increased abuse, prescription outside of approved indications, and availability without a prescription. It has been associated with increased mortality rates, most likely due to its adverse effects on the CVS system.[23]

In quetiapine intoxication, patients should be followed up in the ICU due to the development of life-threatening conditions due to neurologic, CVS, and renal system effects. Therefore, patients may need supportive therapies. In this study, quetiapine overdose was associated with significant toxicity and dangerous complications. In more severe cases of overdose, careful and often prolonged clinical observation is required.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Review

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Combinations of fascial plane block techniques: a new era and broad horizons in anesthesia and analgesia management

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ABSTRACT

The development of ultrasound-guided fascial plane blocks (FPBs) has revolutionized regional anesthesia, extending their use beyond postoperative analgesia toward surgical anesthesia, particularly in high-risk patients. Combining FPBs to target multiple anatomical planes has emerged as a promising approach to achieve broader sensory coverage and improve analgesic efficacy. This review explores clinically relevant combinations of fascial plane block techniques and their applications in various surgical settings. FPB combinations represent a significant advancement in regional anesthesia by optimizing analgesic coverage, reducing reliance on general or neuraxial anesthesia, and improving perioperative outcomes. Despite their growing use, limitations include variability in local anesthetic spread, requirement for high volumes, and incomplete sensory blockade compared with traditional regional techniques. Future prospective studies are needed to confirm their efficacy and define standardized protocols. Nevertheless, FPB combinations constitute a versatile and evolving component of multimodal anesthesia practice.

Keywords: Fascial plane block, block combination, regional anesthesia, analgesia, multimodal analgesia, ultrasound-guided block

INTRODUCTION

Regional anesthesia techniques performed under ultrasound guidance have become increasingly popular in recent years and are now central to anesthetic practice. The term "regional anesthesia", used for over twenty years to describe neuroaxial techniques such as spinal/epidural, has undergone a major evolution over the past decade, focusing on fascial plane blocks (FPBs). The contribution of newly defined plane blocks has been significant in this transformation and in the advancement of regional anesthesia. Gaining popularity due to their simple applicability, ease of learning, and safety profiles, FPBs were initially used primarily for postoperative analgesia but are now also being considered as an alternative anesthetic method to general anesthesia or neuraxial anesthesia in carefully selected high-risk patient groups.[1]

The main efficacy of fascial plane blocks is based on the prospect that the local anesthetic (LA) agent, when administered between two fascial layers, will reach the relevant nerves or neural structures.[2,3] However, the mechanism of action has not been fully proven; for example, mechanisms such as systemic absorption of LA, immunomodulatory effects, and direct innervation of the fascia may also play a role in the efficacy of the Erector Spinae Plane Block (ESPB).[4]

The use of FPBs for analgesia in large areas such as the abdomen and for surgical anesthesia is complex, so clinicians may be uncertain about which block or combination to use in which clinical scenario. At this point, combination blocks that target two anatomical planes and aim to increase the effectiveness of sensory blockage become important. The main mechanism of combinations is to target cutaneous nerve branches that are missed in a single block at a more superficial or deeper fascial plane, cover other nerves innervating the target area, and facilitate the spread of LA beyond the injection site.[1] The spread of high-volume LA

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between different fascial layers can result in different clinical outcomes, and combined approaches play a critical role in targeting anatomical variations.

PROMISING FASCIAL PLANE BLOCK COMBINATIONS FOR SURGICAL ANESTHESIA AND ANALGESIA MANAGEMENT

Fascial plane blocks should be combined to fully cover the targeted area when it is difficult to achieve the complex innervation of the surgical site with a single block. The combinations recommended for the desired surgical areas and their analgesic/anesthetic potentials are discussed below:

Breast Blockade (Combinations for Breast Surgery)

Breast surgery requires blocking a more complex dermatome area than Video-Assisted Thoracoscopic Surgery (VATS) because it also involves the axilla and nipple. In awake breast surgery, due to the use of electrocautery, not only sensory block of the skin but also motor block of the pectoral and serratus anterior muscles is mandatory.[5,6] The breast has a complex innervation (T1-T6 spinal nerves, supraclavicular, pectoral, and intercostobrachial nerves).[6] To cover this innervation, two or more techniques should be used.

PECS-I (Interpectoral) and PECS-II (Pecto-serratus) blocks+SAPB (serratus anterior plane block): The pectoral and serratus anterior muscles can be blocked both motorly and sensoryly with this combination.[6]

PECS II+parasternal block: In order to block those complicated anastomoses in the medial portion of the breast and the midline surgical incision, the Parasternal Block should be added to PECS II and SAPB, which target the lateral and axillary portions of the breast.[7] In order to offer complete analgesic/anesthetic coverage to all dermatome zones (lateral, central, and medial) needed for breast surgery, this triple combination may be effective.

PECS II+RIB (rhomboid intercostal block) or ESPB+PECS-II/SAPB: These methods can be applied to cover the breast and axilla in conjunction with peri-paravertebral blocks.[8]

Combined SAPB (C-SAPB): Postoperative analgesia can be achieved by blocking the lateral cutaneous branches of the thoracic spinal nerves through the SAPB technique.[9,10] In the superficial SAPB approach, in addition to the lateral cutaneous branches, the thoracodorsal and long thoracic nerves are also blocked, resulting in motor blockade. Consequently, in breast and VATS surgeries, C-SAPB not only helps prevent block failure but also provides motor blockade, thereby enhancing analgesic efficacy.[11,12]

Total Abdominal Coverage (Combinations for Extensive and Multiple Dermatome Areas)

The anterior and lateral abdomen are innervated by the T7-T12 thoracoabdominal nerves and the L1 spinal nerve. A single block is obviously insufficient for abdominal surgical procedures that involve large and many dermatome regions.

The blocks and combinations listed below can be utilized to provide anesthesia and significant abdominal analgesia:

Serratus intercostal plane block (SIPB) and rectus sheath block (RSB) combination: This combination works well for both medial and lateral upper abdominal operations.13 While the SIPB targets the lateral cutaneous branches of the thoracic nerves, the RSB aims to be effective in managing midline incision and visceral pain. External oblique intercostal plane block can also be chosen for the lateral abdomen.[14]

Dual TAPB (transversus abdominis plane block) and TAPA/M-TAPA: Target significant portions of the abdominal wall in an attempt to block the T7-L1 nerves.[1]

ESPB and quadratus lumborum block 3 (anterior QLB): Both methods are recommended for large and multiple dermatome areas because of their epidural and paravertebral distribution.[1]

TAPB+transversalis fascia plane block (TFPB): A successful combination for lower abdominal and inguinal procedures performed simultaneously.[15]

Combinations for Sternotomy + Epigastric Thoracic Drain + Chest Tube

The epigastric thoracic drain and chest tube procedures performed in conjunction with sternotomy require blockage of the sternum, the epigastric area, and the anterolateral chest wall.

Parasternal Blocks: Preferred for the sternal area.[16,17]

Rectointercostal Plane Block: It has been described for the substernal regions; epigastrium and subxiphoid.[18]

Thus, the combination of parasternal blocks with rectointercostal plane blocks, which target the anterior midline of the thorax and the epigastrium, will logically comprise a robust method to produce comprehensive anesthesia or analgesia.[19]

SAPB: Following sternotomy procedures, pain caused by the sternotomy line and chest tubes placed along the anterolateral chest wall often leads to significant patient discomfort. In addition to parasternal blocks, the application of SAPB has proven beneficial in alleviating this pain. By performing SAPB-either in its deep or superficial form-effective analgesia of the lateral chest wall can also be achieved.[20]

Combinations for Hip and Knee Surgery

The lower extremity involves complex innervation of the femoral, sciatic, and obturator nerves. It is important to provide analgesia for both the anterior and posterior capsules of the hip and knee.

Combinations for hip surgery (arthroplasty or fractures):

PENG block (pericapsular nerve group) and QLB combination: Whereas QLB targets the posterior capsule innervation and an extensive dermatome region, PENG targets the hip's anterior capsule innervation to provide analgesia.[21]

Lumbar ESPB and anterior QLB combination: This combination can also be used for surgical anesthesia as an alternative to neuraxial and general anesthesia in high-risk patients.[22] The widespread thoracolumbar distribution of ESPB, combined with QLB's ability to block deep areas, can provide comprehensive anesthesia or analgesia without the need for a sciatic nerve block, even in procedures such as femoral neck fracture hemiarthroplasty.

Knee surgery: IPACK block and adductor canal block (ACB) combination:

IPACK block (interspace between the popliteal artery and capsule of the posterior knee): IPACK targets the sciatic nerve branches that innervate the knee joint's posterior capsule, thus it provides analgesia for posterior knee.[23]

ACB: ACB targets the saphenous nerve (sensorial branch of the femoral nerve); it covers the anteromedial part of the knee. This combination provides complete analgesia around the knee and enables mobilization by maintaining the strength of the quadriceps muscle.[24]

The BiFes block, a novel block for the posteromedial region of the knee, can also be added to these combinations.[24]

CONCLUSION AND FUTURE DIRECTIONS

Combinations of fascial plane blocks advance regional anesthesia practice and offer an important alternative that minimizes the risks of general anesthesia in high-risk patients with comorbidities. The use of multiple blocks, such as PECS II + SAPB + Parasternal Block to manage complex innervation in breast surgery, and innovative approaches like PENG + QLB or ESPB + QLB to target both the anterior and posterior capsules in hip surgery, demonstrate the analgesic and anesthetic potential of these combinations.

However, limitations exist, such as the inability to provide more intense nerve blockade compared to traditional regional techniques, dependence on larger volumes of LA, and inconsistent dermatome coverage due to variable distribution patterns. Evidence regarding whether combinations can provide surgical anesthesia is still insufficient, and well-designed, randomized, prospective studies are needed in this area. Nevertheless, the long-term effects of FPB combinations on postoperative analgesia and their advantages in preventing complications associated with general anesthesia make them an indispensable part of modern anesthesia. To fully realize the potential of FPBs in the field of surgical anesthesia, more research is needed to validate the effectiveness of combined methods and novel techniques that take anatomical variations into consideration.

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Referee Evaluation Process

Externally peer-reviewed.

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The authors have no conflicts of interest to declare.

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All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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