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ORIGINAL RESEARCH NEUROANESTHESIA

LMA vs ETT for airway management during general anesthesia for surgical resection of supratentorial tumor; a randomized controlled study

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ABSTRACT

Background & objective: Hypertension is one of the serious complications observed during intubation as well as during awakening from general anesthesia (GA) and extubation. There have been very limited studies reporting the use of Laryngeal Mask Airway (LMA) in craniotomies, although its use has been documented to be associated with less frequency of hypertension compared to endotracheal intubation. We assessed the incidence of emergence hypertension and hemodynamic stability when using Ambu Aura-i intubating LMA compared to the endotracheal tube (ETT) for ventilating craniotomy patients undergoing supratentorial brain tumor surgeries.

Methodology: One hundred and twenty patients participated in this randomized controlled study and were assigned to two groups, the LMA group in which the Ambu Aura-i was used for airway management for GA, and the ETT group in which the ETT were used. The incidence of hypertension on airway device insertion, emergence hypertension and postoperative complications, including cough, sore throat, and hoarseness, were recorded.

Results: The LMA group showed a lower incidence of emergence hypertension when compared to the ETT group (48.3% vs 81.7% respectively; $P < 0.05$). LMA was associated with a lower heart rate (HR), and fewer patients required vasoactive agents during emergence. Moreover, the LMA group expressed a decreased incidence of hypertension with insertion compared to the ETT group (1.7% versus 18.3% respectively; $P < 0.05$), besides a lower incidence of postoperative cough, sore throat, and hoarseness.

Conclusion: The use of Ambu Aura-i intubating LMA for ventilating craniotomy patients undergoing supratentorial brain tumor surgeries showed a lower incidence of emergence hypertension, stable hemodynamics during induction and emergence of anesthesia, and less postoperative complications compared to endotracheal intubation.

Keywords: Airway Management; Craniotomy; Hypertension; Intubation, Intratracheal; Laryngeal Masks.

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1. INTRODUCTION

To have a meticulous anesthesia plan for craniotomy procedures, that targets sustained cerebral perfusion pressure by avoiding sudden fluctuations in the arterial blood pressure as well as intracranial pressures caused by intubation, head-pin application, surgical incision, and emergence, is considered crucial for the outcome .[1]

Any variation in the blood pressure causes disruption of the already impaired cerebral autoregulation in those patients. It may result in cerebral hyperemia and edema leading to elevated intracranial tension causing postoperative intracranial hematoma formation that might necessitate surgical intervention.[2,3]

To provide efficient ventilation for patients during these surgeries, an endotracheal tube (ETT) has been the conventional way of airway management. However, it briefly causes profound hemodynamic fluctuations during intubation and extubation. Consequently, several methods have been tried to control this adverse reaction to endotracheal intubation, including applying topical agents to the trachea, superior laryngeal nerve blockade, use of vasoactive medications (such as esmolol or nicardipine), and use of different airway devices such as laryngeal mask airway (LMA).[4-6]

LMA is widely used for airway management in several orthopedic, obstetric, urological, and gynecological surgeries. Unfortunately, it has a limited role in craniotomy surgeries, being confined to some specific short procedures such as awake craniotomy.[7-9] Ambu® Aura-i™ is a disposable LMA with installation Tube that suits the human airway anatomy, thus facilitating its insertion. Its cuff is designed to be slim and molded to fit the hypopharyngeal space.[10]

This study compared the effect of the use of Ambu Aura-i intubating LMA to the ETT for airway management during general anesthesia (GA) on emergence hypertension and hemodynamic stability, in subjects with supratentorial brain tumors scheduled for craniotomy procedures.

2. METHODOLOGY

2.1. Study population

This randomized, single-blinded, controlled study was done in the neurosurgery operating room of Kasr Al Ainy Hospital (Cairo, Egypt) from December 2020 to June 2023, after approval of the Institutional Ethics Committee (No. MD-202-2020) according to the ethical standards of the Declaration of Helsinki. The trial was registered at ClinicalTrials.gov (No. NCT04582227).

We enrolled 120 patients with supratentorial tumors, aged between 18 and 60 y, ASA- I–II, scheduled for craniotomy. Informed signed consent was obtained from every participant. Those who refused to participate, or had a history of uncontrolled hypertension, cardiac and chest disease, those with a risk of aspiration e.g. body mass index (BMI) ≥ 40, with extensive intracranial tumors that might affect the recovery, or subjects who didn't satisfy the criteria of extubation, were excluded.

A computerized randomization table randomly divided participants into two equal groups of 60 each. All participating subjects were blinded from their allocation. An experienced anesthetist was in charge of the airway management, and another attending anesthetist documented all the needed data throughout the study.

In the LMA group: An LMA (Ambu® Aura-i) was inserted with the conventional single-handed rotational technique and the cuff was inflated to 60 cmH_2O. The seal pressure was then noted while keeping a fresh gas flow rate of 3 L/min into the closed circuit.

In the ETT group: An ETT 7-8 mm internal diameter was inserted under direct laryngoscopic view with a Macintosh blade (size 3–4) and the cuff was inflated to 25 cmH_2O.

2.2. Management protocol

The day before surgery, participants were evaluated by acquiring a thorough medical history, physical examination, and investigations. All subjects received 10 mg of diazepam orally at night.

On the day of surgery, once a 6-hour fasting period was verified, subjects were translocated to the preparation area, where the demographic data and the tumor type were documented, followed by the insertion of a 20-G intravenous cannula. Subjects were then pre-medicated using 0.01 mg/kg of midazolam and 8 mg of ondansetron IV. An arterial cannula was inserted under local anesthesia in the left radial artery for arterial blood pressure monitoring.

Participants were then transferred to the operating room where monitors were applied including a non-invasive blood pressure monitor, electrocardiography, and pulse oximetry. The baseline mean heart rate (MHR) and mean arterial blood pressure (MAP) were obtained before induction.

Following pre-oxygenation via a face mask for 3 min, anesthesia was induced with propofol 2-3 mg/kg, and fentanyl 2-3 µg/kg IV. After confirming loss of consciousness by a BIS score of less than 60 (BISxVR, Aspect Medical Systems, Inc., Norwood, MA, USA), rocuronium 0.6-1 mg/kg was injected. Isoflurane 2–3% was delivered through a facemask until a sufficient level

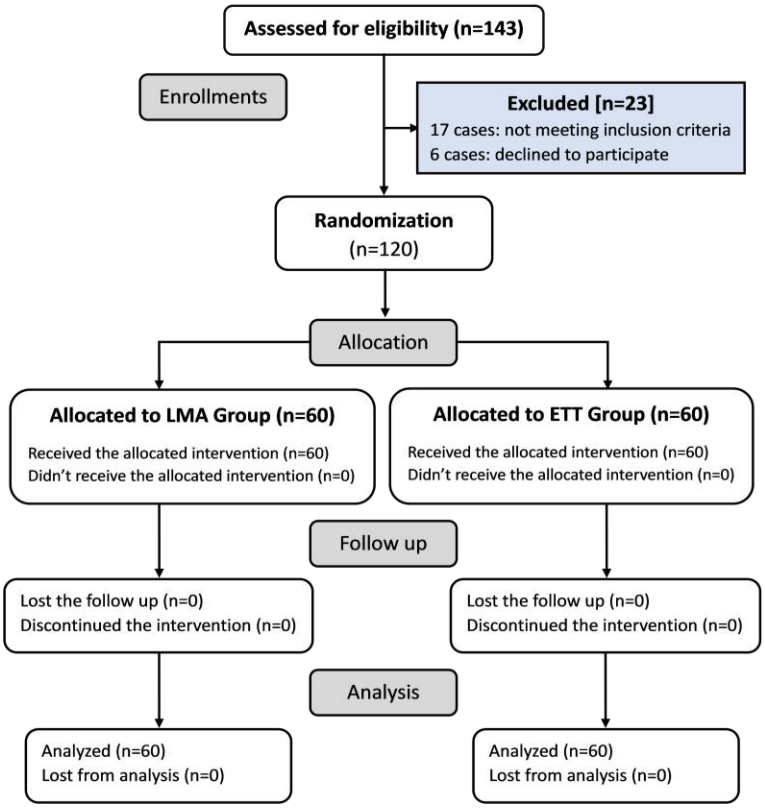


Figure 1: Study flow sheet

of relaxation was attained, then the airway was established using either an ETT for the ETT group or Ambu® Aura-i (Ambu A/S, Ballerup, Denmark) for LMA group. Bilateral breath sounds and end-tidal carbon dioxide level by capnography, confirmed correct placement of the airway. The number of intubation attempts, the time to the first wave appearance on the capnography, and the oropharyngeal leakage pressure (OLP) of the LMA were documented. The feasibility of intubation was scored on a 4-point scale; e.g., 4-very easy; 3-fairly easy; 2-moderately difficult; and 1-difficult). Complications involving airway loss, inadequate oxygenation or ventilation, and bleeding into the airway device were documented, and the subjects were excluded.

Both Inhaled and exhaled tidal volumes and peak and plateau airway pressures were documented following successful intubation, head positioning, and before extubation.

Anesthesia maintenance was done by an air/oxygen mixture with isoflurane, with rocuronium 0.01-0.012 mg/kg/min IV infused. Ventilation was accomplished using 6 mL/kg tidal volume and the respiratory rate was set to attain an $EtCO_2$ of 35-40 mmHg. Scalp block was done with lidocaine 2 mg/kg plus bupivacaine 1 mg/kg in a 30 mL solution of epinephrine 1:100000 in normal saline 0.9%, to minimize the stress response to surgical incision and pins insertion.

A bolus of fentanyl 0.5 µg/kg was used to manage any hypertension (MAP > 25% of baseline), or a bolus of esmolol 1 mg/kg or nitroglycerine infusion was considered.

At the end of the surgery, rocuronium infusion was discontinued upon dura closure, followed by stopping isoflurane administration and reversing the neuromuscular blockade with sugammadex 2 mg/kg. The airway device was removed when the patient was cooperative, oriented, and able to follow verbal instructions. The device was examined for any blood stains after removal. The duration of the surgery (min), and the emergence time were recorded. Participants were then shifted to the post-anesthesia care unit (PACU) and modified Aldrete's score (MAS) was used to assess recovery characteristics upon arrival to the PACU and every 30 min for 2 h. Patients were discharged when MAS was > 9.

Postoperative complications, including convulsion, hematoma formation, nausea and/or vomiting, re-exploration, hypoventilation, reintubation, and aspiration. On the second postoperative day, participants were assessed for sore throat, cough, and hoarseness by the scoring system of Harding and McVey.[11]

2.3. Data collection

The primary outcome was the incidence of emergence hypertension. The secondary outcomes included hypertension associated with airway device insertion, failure to establish an airway, the number of attempts to install an airway device successfully, and the postoperative complications.

2.4. Statistical analysis

Power analysis was done using the G*power 3.1.9.2 program (Universitat Kiel, Germany) for the incidence of emergence hypertension in patients as the main outcome of this study. A previous study reported that the incidence of emergence hypertension in neurologic surgery was 91%.[12] We computed a sample size that may

Table 1: Comparative demographic data of the studied groups

Variable	LMA group (n = 60)	ETT group (n = 60)	P-Value
Age (y)	40.95 ± 10.96	44.17 ± 11.67	0.122
Gender (M/F)	33/27	35/25	0.854
BMI (kg/m^2)	28.66 ± 2.27	28.11 ± 2.16	0.174
ASA (I/II)	32/28	34/26	0.855
Comorbidity			
• Controlled Hypertension	6 (10)	5 (8.3)	0.590
• Diabetes	6 (10)	10 (16.7)	
• Controlled Hypertension + Diabetes	9 (15)	8 (13.3)	
• Asthma	7 (11.7)	3 (5)	
MMC classification I/II	26/34	17/43	0.127
El-Ganzouri score	2 (2)	2 (2)	0.465
Tumor type M/G/O	21/20/19	15/25/20	0.454
Duration of anesthesia (min)	333.43 ± 54.47	323.52 ± 46.98	0.288

Data are presented as the mean ± SD, median (IQR), and n (%)

BMI, body mass index;; MMC, modified Mallampati classification; M/G/O, Meningioma/ Glioma/ Other

detect a 30% reduction in the incidence of emerging hypertension when Ambu Aura-i LMA was used instead of ETT. A minimum number of 54 patients per group was required to have a study power of 95% and an alpha error of 0.05. The number was increased to sixty patients per group to compensate for any drop-outs.

For data analysis, the Statistical Packages for the Social Sciences software v25.0 (SPSS, Inc., Chicago, IL, United States) was used. Categorical data was presented as frequency (%) and analyzed using Fischer's exact test and Chi-square test. The Shapiro-Wilk test was used to check the normality of continuous data. When analyzing normally distributed data, the unpaired t-test was used for single measures, and two-way analysis of variance (ANOVA) was used for repeated measures and the data was presented as mean ± standard deviation. The median (IQR) revealed the data that were not normally distributed (by the Kolmogorov–Smirnov test) and was analyzed with the Kruskal–Wallis test, as appropriate. $P < 0.05$ was considered as statistically significant.

3. RESULTS

In this study, one hundred forty-three patients undergoing elective craniotomy procedures under GA were enrolled. Twenty-three patients were excluded from the study, 17 of which didn't fulfill the inclusion criteria, while 6 declined participation. The remaining one hundred twenty patients were allocated to two groups, sixty patients each, who finalized the study (Figure 1).

No noticeable differences were found between both groups regarding patients' demographic characteristics (age, gender, BMI, ASA, comorbidities, modified Mallampati classification, El-Ganzouri score, and tumor type) and the surgery duration (Table 1).

A successful first attempt intubation was achieved in 55 (91.7%) participants in the LMA group and 51 (85%) subjects in the ETT group ($P = 0.394$). However, the average time needed for airway device insertion was decreased in the LMA group, compared to the ETT group ($P < 0.05$). In the LMA group, no subjects required ETT insertion for the cause of inability to establish an airway after two attempts, moreover, in the ETT group, there was no incidence of failed intubation. The incidence of hypertension associated with device insertion was significantly lower in the LMA group, compared to the ETT group ($P = 0.004$). There was no noticeable variation in ventilation parameters between both groups (Table 2).

The incidence of emergence hypertension showed a significant decrease in the LMA group compared to the ETT group ($P = 0.000$). Moreover, the need for vasoactive drugs was remarkably more frequent in the ETT group compared to the LMA group as 40 participants in the ETT group and 27 in the LMA group needed esmolol, also eight participants in the ETT group and two participants in the LMA group needed nitroglycerine infusion with esmolol, during anesthesia recovery. Intraoperative fentanyl requirement was

Table 2: Comparative insertion-related parameters between the studied groups.

Parameters		LMA group (n = 60)	ETT group (n = 60)	P-value
Time taken for insertion (sec)		29.73 ± 9.43 *	34.87 ± 12.09	0.011
First attempt success rate		55 (91.7)	51 (85)	0.394
Second attempt success rate		5 (8.3)	9 (15)	
OLP (cmH_2O)		23.88 ± 2.85	0	
Incidence of hypertension on airway device insertion		1 (1.7) *	11 (18.3)	0.004
After insertion	Inhaled TV (mL)	509.75 ± 19.12	503.52 ± 38.57	0.264
	Exhaled TV (mL)	492.20 ± 20.25	502.63 ± 38.62	0.066
	Peak airway pressure (cmH_2O)	17.18 ± 1.83	16.80 ± 1.35	0.194
	Plateau airway pressure (cmH_2O)	13.62 ± 1.38	13.30 ± 1.21	0.184
After position	Inhaled TV (mL)	509.02 ± 23.88	505.95 ± 38.29	0.600
	Exhaled TV (mL)	494.28 ± 27.33	504.95 ± 38.29	0.082
	Peak airway pressure (cmH_2O)	18.68 ± 2.02	18.02 ± 2.66	0.125
	Plateau airway pressure (cmH_2O)	14.73 ± 2.59	14.42 ± 2.80	0.505
Before extubation	Inhaled tidal volume (mL)	496.08 ± 24.30	504.95 ± 38.29	0.827
	Exhaled tidal volume (mL)	496.08 ± 24.30	523.28 ± 49.68	0.133
	Peak airway pressure (cmH_2O)	18.02 ± 2.66	17.65 ± 1.50	0.354
	Plateau airway pressure (cmH_2O)	14.42 ± 2.60	14.08 ± 1.46	0.389
Ease of insertion; easy/fair/difficult (n)		51/5/4	47/11/2	0.214

Data are presented as the mean ± SD, or n (%); P < 0.05 considered significant.

significantly lower in the LMA group (P = 0.017) (Table 3).

MAP and HR were noticeably higher in the ETT group for the following time points; immediately after intubation, following spontaneous breathing (for HR only), five minutes before extubation, at extubation, and five minutes after extubation (for MAP only). Otherwise, they were comparable in the other time points (Figure 2).

Regarding the postoperative time, no differences were noted in the ICU or hospital stay in both groups.

However, there was an unremarkable variation between both groups regarding postoperative complications, except for the incidence of cough, sore throat, and hoarseness, which were lower in the LMA group when compared to the ETT group (P < 0.05) (Table 4).

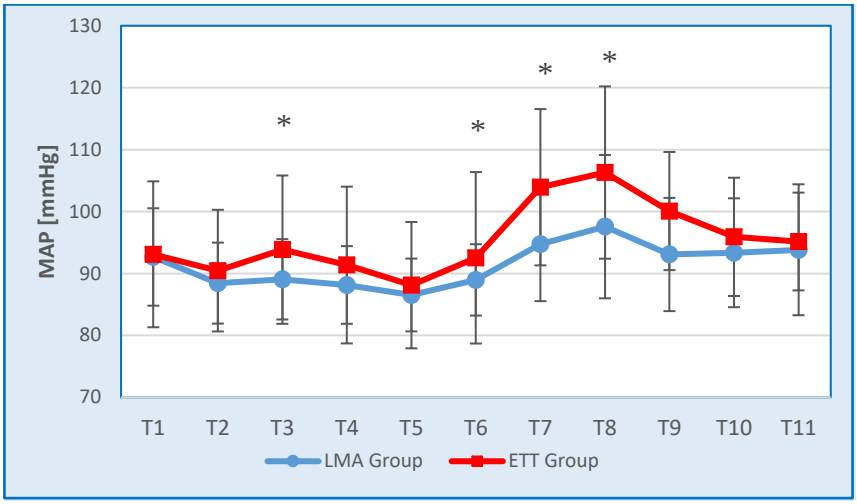
4. DISCUSSION

In the current study, the use of Ambu® Aura in cases undergoing craniotomy procedures for supratentorial brain tumor excision has shown superiority over using the conventional ETT. It showed a significant decrease

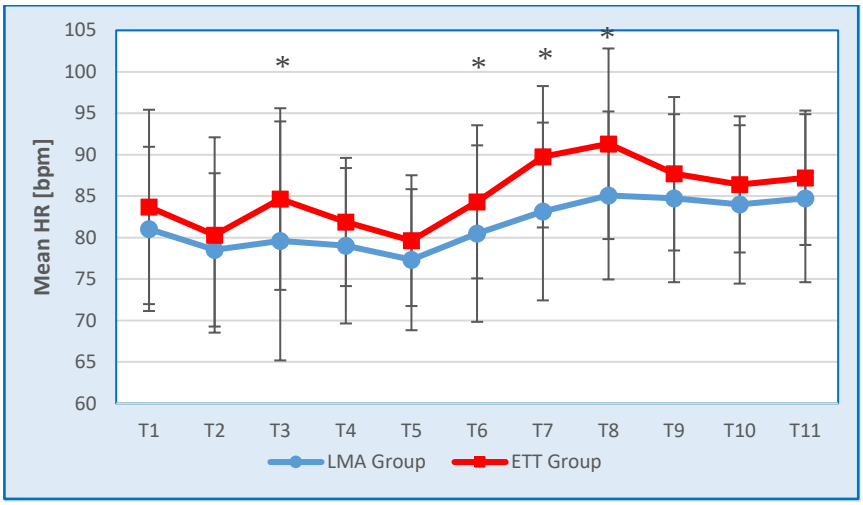
Table 3: Emergence characteristics and anesthetic data in the two groups

Variable	LMA group (n = 60)	ETT group (n = 60)	P-Value
Emergence time (min)	22.73 ± 5.34	24.28 ± 5.88	0.133
The incidence of emergence hypertension	29 (48.3) *	49 (81.7)	0.000
Application of vasoactive drug (E/E+N)	27/2 *	40/9	0.001
Sevoflurane consumption (mL)	85.43 ± 14.37	82.25 ± 13.20	0.209
Total Intraoperative fentanyl used (µg)	184.33 ± 32.01*	199 ± 34.28	0.017

Data are presented as the mean ± SD, and n (%).; P < 0.05 considered significant.
E/E+N, esmolol / esmolol + nitroglycerine infusion



(A) Mean arterial blood pressures



(B) Mean heart rate

Figure 2 (A & B): Comparison of the mean arterial blood pressure and mean heart rate between the two groups; *T1, before the anesthesia induction; T2, Following anesthetic induction but 5 min before tracheal intubation; T3, immediately following successful intubation; T4, 5 min after intubation; T5, one-hour following intubation; T6, after initiating spontaneous breathing; T7, 5 min before extubation; T8, at time of extubation; T9, 5 min after extubation; T10, 10 min after extubation; T11, at recovery room (Data are presented as the mean ± SD. P < 0.05 considered statistically significant)*

in the prevalence of emergence hypertension, with morestable hemodynamic parameters during emergence from anesthesia. Moreover, it showed a lower incidence of postoperative complications in the LMA group compared to the conventional ETT group.

Supratentorial tumor procedures are considered some of the most complex cases in the neurosurgery setting. They require a high degree of cooperation between the surgical and anesthesia teams for the best outcome. Anesthesia challenges include the necessity of fully comprehending the means to avoid secondary brain insults by maintaining the intracranial pressure and cerebral perfusion, as well as the management of possible intraoperative complications e.g., hemorrhage and air embolism.[13,14]

The effect of anesthesia on brain physiology has been of great concern in neurosurgery cases, due to occurrence of several undesirable reactions including hemodynamic fluctuations and emergence hypertension. A variety of causes have been suggested for the emergence hypertension phenomenon,.[15,16] It is mostly explained by a sympathetic response with an acute transient rise in serum catecholamines release causing peripheral vasoconstriction with a decrease in the sensitivity of baroreceptors. Other contributing factors include direct brain manipulation causing neurogenic hypertension, renin-angiotensin-aldosterone system activation, and perioperative pain.[17,18] Thus, many studies have been dedicated to reducing the prevalence of these drawbacks, some of which introduced the idea of replacing the traditional ETT with an LMA for its proven benefits in other surgical cases.

The use of the LMA has been proven to be associated with lower plasma norepinephrine levels at various stages including post-insertion and emergence, compared to ETT insertion. Hence, it helps in achieving hemodynamic stability and avoiding the emergence hypertension.[19,20] This advantage is of great value, as even minor hemodynamic changes can be critical for patients undergoing intracranial surgeries.[21] Moreover, the feasibility of LMA insertion in a shorter time interval,

and rapidly achieving effective ventilation is crucial for patients with unexpectedly difficult airways, as prolonged apnea causing hypercapnia can drastically affect the outcome of neurosurgery procedures.[22,23]

stability when compared to performing deep extubation of the ETT.[26,27]

Hurtado P et al. also performed a study to compare the outcome of using ETT to replace the ETT with a LMA,

Table 4. Postoperative characteristics and complications.

Parameter		LMA group (n = 60)	ETT group (n = 60)	P-value
Duration of ICU stay (day)		1.38 ± 0.56	1.55 ± 0.65	0.133
Duration of hospitalization (day)		3.68 ± 0.65	3.85 ± 0.82	0.220
Complications	Convulsions	0 (0)	2 (3.3)	0.496
	Hematoma formation	1 (1.7)	3 (5)	0.619
	Hoarseness	10 (16.7) *	23 (38.3)	0.013
	Hoarseness score	0 (0) *	0 (1)	0.002
	Sore throat	20 (33.3) *	35 (58.3)	0.010
	Sore throat score	0 (1) *	1 (2)	0.000
	Cough	10 (16.7) *	38 (63.3)	0.000
	Cough score	0 (0) *	1(2)	0.000
	Nausea and vomiting	15 (25)	21(35)	0.319
	Re-exploration	0 (0)	2 (3.3)	0.496
	Hypoventilation	5 (8.3)	3 (5)	0.717
	Reintubation	4 (6.7)	2 (3.3)	0.679
	Blood staining of airway device	8 (13.3)	3(5)	0.204
	Aspiration	0	0	0

*Data presented as mean ± SD, median (IQR), and n (%); * Significantly lower than the ETT group (P < 0.05).*

***Hoarseness Score:** 0 = No evidence of any time the time since the operation; 1= w of time the at hoarseness of evidence, 1= No evidence of hoarseness at the time of interview, 2= Hoarseness at the time of interview noted by patient only, 3 = Hoarseness that is easily noted at the time of interview*

***Sore throat Score:** 0 = No sore throat at any time since the operation, 1 = Minimal sore throat (Complains of sore throat only on asking), 2 = Moderate sore throat (Complains of sore throat on his / her own), 3 = Severe sore throat (Complains of throat pain)*

***Cough Score:** 0 = No cough at any time since the operation, 1 = Minimal cough or scratchy throat (Light or single episode of cough), 2 = Moderate cough (more than one episode of non-sustained cough), 3 = Severe cough (Sustained and repetitive cough with head lift).*

A study conducted by Perell o-Cerda` et al. on 42 patients undergoing supratentorial craniotomy where a ProSeal LMA replaced the ETT before emergence from anesthesia, showed a decreased incidence of hemodynamic instability, as well as a decrease in the incidence of cough and cerebral hyperemia. However, in our study, the LMA was used throughout the procedure.[24] Zhang et al. also agreed with the results of our study, where using Ambu® AuraOnce™ LMA was compared to ETT during craniotomy procedures, causing more hemodynamic stability and lower incidence of emergence hypertension, with decreased prevalence of cough and postoperative sore throat.[25] Some other studies proved that replacing the ETT with an LMA device before emergence decreased the incidence of cough, and was associated with more hemodynamic

in patients undergoing pituitary surgery. It proved that using LMA resulted in more stability of the hemodynamics and lower risk of CSF leakage postoperatively due to lower cough incidence.[28]

5. LIMITATIONS

We did not measure intracranial pressure, which interfered with obtaining direct data on the main target. Also, it was performed at a single center.

6. CONCLUSION

The use of Ambu Aura-i in craniotomy surgeries achieved a lower incidence of emergence hypertension,

better hemodynamic stability during induction and emergence of anesthesia, and a decreased prevalence of postoperative complications including cough, hoarseness, and sore throat compared to ETT.

7. Future direction

The result of our study warrants further investigation with the inclusion of a wider spectrum of craniotomy surgeries and the use of the 2nd generation of LMAs.

8. Data availability

The numerical data related to this study is available with the authors.

9. Conflict of interest

The authors report no conflict of interest. This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

10. Authors' contribution

AK and NF: concept, study design, analysis and interpretation, writing the manuscript

AK, KE, and AI study design

AS, AI: data collection, AK and AS were responsible for analysis and interpretation, and writing the manuscript

NF, KE: revision of the manuscript

All authors have read and approved the final manuscript. The corresponding author agreed to be accountable for all aspects of the work

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