Original article

Application of Laryngeal Mask Airway (LMA) in Medium and Short Period Traumatic Orthopedic Surgeries

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Abstract:

Objective: Application of Laryngeal Mask Airway (LMA) as a ventilation method has been rarely explored in short and medium period orthopedic operations. In this study, we evaluated ventilatory efficacy of LMA in patients admitted to Ho Chi Minh City Orthopedic and Rehabilitation Hospital, Vietnam via a number of patient indicators including changes of pulse, blood pressure, airway pressure, SpO_2 and pressure of CO_2 at the end of an exhaled breath (EtCO2). ***Method:*** A total of 154 emergency and elective surgery cases with anesthesia were selected for the study. ***Result:*** One minute after LMA insertion to discontinuation of anesthetic, we recorded slower pulse of patients but only twenty-six cases (16.9%) required intravenous administration of atropine. Blood pressure of patients dropped after 1 minute following LMA insertion but then recovered afterward and only nine cases (5.8%) needed administration of ephedrine. ***Conclusion:*** After surgery, only eleven (7.15%) patients experienced oral mucosal bleeding but no further special treatment was used.

Keywords: Laryngeal mask airway (LMA); Traumatic Orthopedic surgery; Coronavirus; Research; Medical residency; Training; Obstetrics; Gynecology

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Introduction:

Most traumatic orthopedic surgeries are medium and short operations (1-2 hours) and thus typically involve brachial plexus block anesthesia with operations in the upper arms, shoulder joints and clavicles, or spinal anesthesia with operations in the lower extremities [1–9]. However, those techniques could not guarantee the absolute success rate even with the most experienced anesthetists and could be associated with a number of complications [10–12].

Common complications with anesthesia of brachial plexus block include local anesthetic allergy and local anesthetic systemic toxicity (LAST), damage of nerves of blood vessels and increased likelihood of administration of painkillers, which poses risk to respiratory control for patients. In addition, brachial plexus block anesthesia has a long waiting time (approx. 20-25 minutes) and may involve switching from regional to general anesthesia for surgeries that have been prolonged unexpectedly [13]. For spinal anesthesia, disadvantages might include drop of blood pressure, slow pulse, urinary retention, prolonged paralysis, back pain and high failure rate (around 3-5%) [11].

Application of Laryngeal mask airway (LMA), a type of supraglottic airway device, for general anesthesia has been widely adopted in short, one-day surgeries [14–17]. One of the advantages of LMA is that it approaches the airways very quickly without the need for muscle relaxants [18, 19]. Compared with regional anesthesia methods, LMA does not involve long waiting time, causes little anxiety and

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stress to both patients and surgeons and does not necessitate the use of other medications except for painkillers [18]. Furthermore, because LMA does not require extensive post-anesthesia care, successful implementation of this procedure might carry important implications of increasing turnover for operating rooms in orthopedic hospitals with high patient admission and limited resources [20].

To our knowledge, application of LMA in orthopedic surgeries has not been fully explored. In this study, we examined the possibility of using of LMA for short and medium orthopedic surgeries as an effective ventilation method that ensures safe circulation and respiration. To be specific, we first evaluate ventilatory efficacy of LMA in a sample of patient in X Hospital, Vietnam. A number of indicators of patients including stability of pulse, blood pressure, SpO_2 were assessed and adverse effects of LMA were monitored.

Method and Materials:

The sample of this study was recruited at Anesthesia Department of the X Hospital, Vietnam from March to September 2018. A total of 154 operative cases with anesthesia were selected for the study. The included operations were both emergency and elective surgeries where LMA usage is not contraindicated. Selected patients were undergoing limb, body skin grafting and body skin excision surgery. Patients with respiratory inflammation, obesity (BMI≥30 kg/m^2), pregnancy (>4 months), face-down position surgery, and cases whose anesthesia method had to switch to intubation insertion were excluded in the study.

During pre-anesthesia, patients were pre-medicated with i.v. ranitidine 50mg, i.v. midazolam 0.01-0.03mg/kg, and i.v. fentanyl 2-2.5 mcg/kg. Afterwards, i.v. propofol was administered with the dose of 1.5-2.5 mg/kg for 20 seconds for induction of anesthesia [21]. LMA was inserted when applicable. Then air was pumped and the tightness of LMA was ensured [22]. Other parameters included mechanical ventilation at Vt=6-8ml/kg, fresh air at 2L/minute, breathing frequency 12 times/minute, average airway pressure at 10-16 cmH_2O, $EtCO_2$= 30-40 cmH_2O.

The anesthesia was maintained with sevorane at level of 3-4%. The depth of anesthesia was assessed by PRST. The concentration of respiratory anesthesia was increased when PRST >3. Propofol could be increased by 1mg/kg if the PRST remained unchanged or if there was any abnormal movement of the patient [21]. If the patients resumed breathing early, esmeron 0.04-0.06mg/kg would be further administered for muscle relaxation. Administration of anesthetic agents stopped 10-15 minutes prior to the end of surgery. LMA was removed as soon as patients regained consciousness and were able to respond to commands, SpO_2 ≥ 98%, breathing frequency ≥10 times/minute. Patients were transferred to recovery room when the breathing became regular at 10 times/minute, no mucus stagnation, and at SpO_2 ≥ 96% at outdoor air breathing.

We monitored following indicators of patients: average airway pressure (cmH_2O), airway leak pressure (cmH_2O), pressure of CO_2 at the end of an exhaled breath ($EtCO_2$-mmHg), LMA insertation time (second), pulse, blood pressure and SpO_2. The parameters were recorded at patient admission (T0), 1 minute after pre-anesthesia (T1), 1 minute after LMA insertion (T2), during operation (T3), anesthetic discontinuation (T4) and after LMA was removed (T5). In addition, the occurrence of any complications such as oral mucosal bleeding, sore throat, hoarseness, dysphagia, reflux and choked gasp was noted during emergence.

Results:

Characteristics of surgeries:

Table 1 and 2 summarized demographics, medical background of patients and surgeries. Regarding demographics of patients, there was the predominance of male patients and most of the subjects were in young age with the largest age group was between 20 to 59, which is consistent with the working age where younger patients are more prone to accidents than older patients. The average age of patients was 36.5. However, there existed a large age gap between included patients. This is due to the admission of senior patients with infectious foot complications from department for diabetic foot care and long healing wound care. Because those patients have to undergo multiple wound treatment surgeries and cannot be regionally anesthetized multiple times in a week, we need to employ general anesthesia instead of regional anesthesia.

Most of the patients had BMI below 25. There are only 7 cases with BMI ≥ 25kg/m^2. We did not include obese patients with BMI>30 because their abdominal pressure tends to be high, which can easily lead to reflux and choked gasp during anesthesia [23, 24]. More than half of the sample were healthy and had ASA type I. The rest of the patients suffered from hypertension, cardiovascular, diabetes and respiratory diseases. Of

Table 1: Demographics, BMI, ASA and Mallampati score of patients

Age (year): youngest/oldest/average	7/92/36.5
Gender: Male / Female (%)	105/49 (68/32)
Mean height (cm) / weight (kg) / BMI (kg/m²)	161/54/20
ASA: I/II/III (%)	84/66/4 (55/43/2)
Mallampati: I/II/III	66/81/7
Mean anesthesia duration / surgery duration (minute)	56.17/50.40

Table 2: History and background of patients

Background disease	Quantity	Rate (%)
Hypertension	9	5.8
Cardiovascular disease	6	3.9
Respiratory disease	7	4,5
Diabetes and other metabolic diseases	22	14.3
Others	26	16.9

Table 3: Characteristic of surgeries

Classification of surgery	Quantity	Rate (%)
Lower extremity	78	50.7
- Tibia fixation	22	
- Foot bone fixation	6	
- Amputation	10	
- Debridement, skin grafting	40	
Upper extremity + clavicle	48	31.1
Others	28	18.2
Total	154	100

which, there are 22 cases of diabetes (14.3%) with ASA type II and III.

Table 3 has shown that half of the study patients were operated on lower extremity including bone fixation and amputation. All these types of surgery were previously performed under spinal anesthesia. The rest of the surgeries were foot bone fixation and skin grafting. A skin graft is often taken from thigh. Of all cases in upper extremity, shoulder joint and clavicle related surgeries take up 48 cases (31%). Previously, these surgeries were anesthetized with the brachial plexus block. Due to the pharmacological nature of the anesthetic, the waiting time starting from the completion of the anesthesia to the point where the operation could be conducted usually ranges from 25 to 30 minutes. In addition, it also takes about 5 minutes to perform the anesthesia procedure. Therefore, the total waiting time since the patient admission to the actual surgical procedure might be at least 30 minutes. This might cause stresses to the patients and reduces rotation efficiency of operating rooms.Average anesthesia duration in our study is 56.17 minutes (fastest: 7 minutes; longest: 180 minutes). Average surgery time is 50.4 minutes (fastest: 5 minutes, longest 190 minutes). These durations are compatible to recommendations for LMA anesthesia, which are medium and short period surgeries. Anesthesia time is longer than surgery time, which understandable given the necessity to take care of patients' wound and apply surgical drape. There are some cases where, the anesthesia time is significantly shorter than the surgery time. Although this seems unreasonable, closer examination of those cases reveals that those cases mostly comprise amputation and skin grafting cases on elderly or weak patients, which does not usually require full-duration anesthesia. As a result, we deliberately cut off anesthetic early and let the patients to breathe on their own for the remaining time, resulting in surgery time longer than anesthesia time. Of all operation cases, most of them were successful from the first time of insertion (131 cases, 85%) and were carried out very quickly with the duration averaged at around 47.9 seconds (fastest: 10 seconds, longest: 180 seconds). During brachial plexus block, it takes us at least 5 minutes to perform the procedure followed by the waiting time of 25 – 30 minutes. This period of time means a lot to operating room, surgeons and patients. The rotation of operating room will be faster, which means that productivity increases. This helps relieve the stress and cut short the waiting time for the surgeons [13]. Especially, the patients will be freed from waiting in distress. The waiting time can be shorter in case of spinal anesthesia compared to plexus block; however, it entails risks of hypotension and slow pulse. Moreover, other complications including back pain, urinary retention and dizziness are factors that hinder the process of early discharge in day surgery [11].

Average airway pressure, airway leak pressure and $EtCO_2$: The airway pressure was measured one minute after the LMA was placed, at which point the patients are stabilized and the surgery can begin (Table 4). The average airway pressure recorded is 13.54 cmH_2O (maximum: 22, minimum: 10). Our current result is lower than those of Brimacombe where airway pressure was recorded as 18±5 cmH_2O [24] and is similar to findings reported by Lorenzo et al. [25]. This result is due to absence of ventilator during surgery and the presence of some patients with very low BMI. Theoretically, those with high BMI have high airway pressure. In addition, almost half of patients in the sample were weak (ASA II and III) and thus did not require high airway pressure to maintain normal breathing.

Table 4: Average airway pressure, airway leak pressure, pressure of CO_2 at the end of an exhaled breath

	Minimum	Maximum	Average
Average airway pressure (cmH_2O)	10	22	13.54
Airway leak pressure (cmH_2O)	12	48	29.08
Pressure of CO_2 at the end of an exhaled breath (mmHg)	20	50	35.78

Average airway leak pressure is measured as 29.08 cmH2O (12-48). This pressure is ranged within the standard range of 40-45 cmH_2O and safe for the patients. It is recommended that airway leak pressure should not be over 40-45 cmH_2O because additional air must be pumped to fill the LMA cuff in order to achieve closed pressure, which might accidentally damage the oral and pharyngeal mucosa of the patients [23]. Pressure of CO_2 at the end of an exhaled breath reflects the gas exchange in the lung. The normal value for this parameter in healthy people is 35-45 cmH_2O. This value will be low if the ventilator is leaky. Our study has documented the result of 35.78 cmH_2O, which is perfectly normal and compatible to that of other authors [26]. In conclusion, the values of average airway pressure, airway leak pressure and pressure of CO_2 at the end of an exhaled breath are stable within the permissible limit, which indicates that the ventilatory efficacy of LMA is guaranteed.

Stability of pulse and blood pressure: We define "slow pulse" as cases whose pulse is reduced by more than 25% compared to baseline pulse or is less than 50 times/minute and lasts for more than 2 minutes at any time during the anesthesia process. Current results revealed that there are 30 cases of slow pulse and twenty-six (16.9%) of which needed intravenous administration of atropine at a dose of 0.5-0.75mg (Table 5). Pulse decreases statistically at T1 to T4 compared to T0. This is due to increased patient anxiety at the time of reception, causing fast pulse. The patients were then given midazolam and the induction of anesthesia begins followed by anesthesia process resulting in decreased pulse compared to the time of reception.

Table 5: Changes in pulse at certain time

Pulse	T0	T1	T2	T3	T4	T5
Min	52	54	47	53	33	55
Max	143	135	120	118	122	128
Average	84.69	82.85	76.81	78.34	79.12	82.71
Standard deviation	17.58	16.24	15.48	14.95	14.77	13.76
P value*		0.009	<0.001	<0.001	<0.001	0.104

*Paired Samples T-Test (compared with T0)

Blood pressure and SpO_2 progression of patients during anesthesia was summarized as in Figure 1. We observed that after anesthesia induction, the blood pressure decreased remarkably at T2 and T3 (after the insertion of LMA and during the operation). After that, blood pressure slowly recovered. Toward the end of the operation, both systolic blood pressure and diastolic blood pressure would reach the blood pressure recorded at the time of reception.

We noticed that all of the low blood pressure cases occur immediately following the induction of anesthesia. This is totally consistent with the pharmacological property of propofol, which decreases blood pressure with the first dose but rarely does with repeated doses [21]. We also recorded 141 hypotension cases (91.6%), in which only 9 cases (5.8%) need ephedrine administration. Given that the low blood pressure cases are only transient, it only took some simple measures to normalize the blood pressure including fluid flow adjustment, lowering the concentration or cutting off respiratory anesthesia completely.

Lastly, it seemed that LMA does not increase blood pressure following the induction of anesthesia. This is because LMA insertion stimulate little on oropharyngeal while intubation does increase pulse and blood pressure at this time [18].

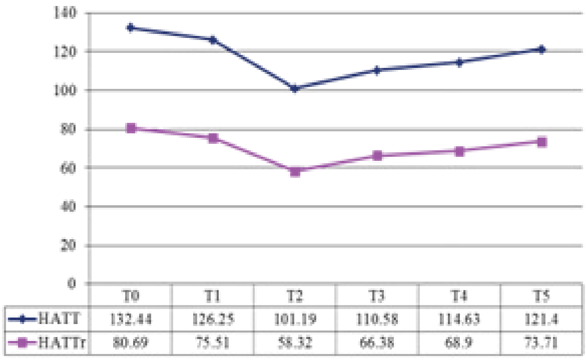

Figure 1: Changes in blood pressure of patients during anesthesia

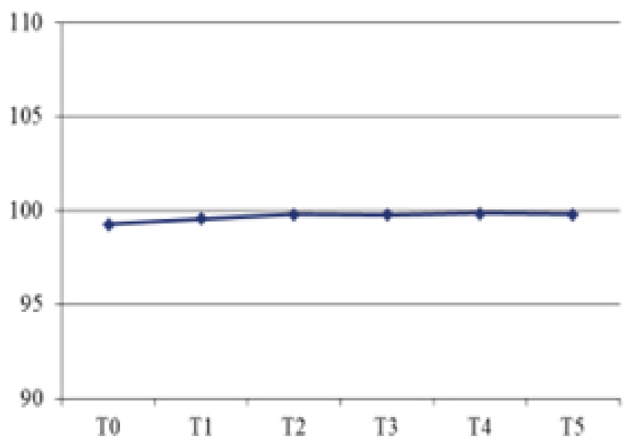

Figure 2: Changes in SpO_2 of patients during anesthesia

Adverse effects of LMA:

Table 6 summarizes numbers of complication occurrences of the patients. Normally, the adverse effects of LMA are bleeding, oral mucosal bleeding, sore throat, hoarseness, dysphagia, reflux and choked gasp [27, 28]. Fan et al reported two cases rupture of tracheal when intubation: one using stylet, and one was due to overinflation [29]. However, there are only 11 cases of oral mucosal bleeding (7.1%). These cases are not serious thus do not need any special treatment. We also monitored cases that required repeated intubation (2-3 times) and recorded no cases of sore throat, hoarseness and dysphagia.

We also did not record any cases of reflux and vomit during induction of anesthesia. All of the patients had light meals one day before followed by 6-8 hour of fasting. In the operating room, our patients are given an injection of ranitidine intravenously and there is no sign of reflux or vomiting. Therefore, we concluded that compliance with the fasting period is the most important prerequisite for LMA application, followed by sufficient doses of anesthesia and good LMA insertion technique.

Table 6: Adverse effects of LMA

Adverse effects	Quantity	Rate (%)
Stimulation	0	0
Oral mucosal bleeding	11	7.15
Sore throat, hoarseness, dysphagia	0	0
Reflux	0	0

Conclusion:

We examined the possibility of applying LMA ventilation as a procedure for general anesthesia in medium and short-period orthopedic surgeries. The use of LMA ensured effective ventilation in all patients undergoing orthopedic surgeries as indicated by stable average airway pressure, airway leak pressure and pressure of CO_2 at the end of an exhaled breath. Regarding pulse of patients, we recorded slower pulse of patients from 1 minute after LMA insertion to discontinuation of anesthetic and only twenty-six cases (16.9%) required intravenous administration of atropine due to slow pulse. Blood pressure of patients dropped after 1 minute following LMA insertion but then recovered afterward and only nine cases (5.8%) needed administration of ephedrine. Regarding adverse effects after surgery, only eleven (7.15%) patients experienced oral mucosal bleeding but did not undergo no further special treatment. There were no cases which LMA insertation was unsuccessful and had to switch to intubation.

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