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Role of laryngeal mask airway in laparoscopic cholecystectomy

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Abstract

Laparoscopic cholecystectomy is one of the most commonly performed surgical procedures and the laryngeal mask airway (LMA) is the most common supraglottic airway device used by the anesthesiologists to manage airway during general anesthesia. Use of LMA has some advantages when compared to endotracheal intubation, such as quick and ease of placement, a lesser requirement for neuromuscular blockade and a lower incidence of postoperative morbididy. However, the use of the LMA in laparoscopy is controversial, based on a concern about increased risk of regurgitation and pulmonary aspiration. The ability of these devices to provide optimal ventilation during laparoscopic procedures has been also questioned. The most important parameter to secure an adequate ventilation and oxygenation for the LMA under pneumoperitoneum condition is its seal pressure of airway. A good sealing pressure, not only state correct patient ventilation, but it reduces the potential risk of aspiration due to the better seal of airway. In addition, the LMAs incorporating a gastric access, permitting a safe anesthesia based on these commented points. We did a literature search to clarify if the use of LMA in preference to intubation provides inadequate ventilation or increase the risk of aspiration in patients undergoing laparoscopic cholecystectomy. We found evidence stating that LMA with drain channel achieves adequate ventilation for these procedures. Limited evidence was found to consider these devices completely safe against aspiration. However, we observed that the incidence of regurgitation and aspiration associated with the use of the LMA in laparoscopic surgery is very low.

Key words: Laryngeal mask airway; Laryngeal mask airway Proseal; Laryngeal mask airway Supreme; I-gel; Laparoscopic cholecystectomy; Oropharyngeal leak pressure; Ventilation

Core tip: Use of the laryngeal mask airway (LMA) in laparoscopy is controversial, largely because of a concern about increased risk of regurgitation and aspiration, also due to an inadequate or suboptimal ventilation of the patient during these procedures. We performed the first review of this topic and we found evidence to recommend the LMA with gastric access in laparoscopy for selected patients based on its ability for optimal ventilation. A potential risk of aspiration cannot be totally rejected, however, clinical performance using these devices has reported a very low incidence of aspiration-related morbidity, so future research may provide some evidence about this topic.

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INTRODUCTION

Laparoscopic cholecystectomy is one of the most commonly performed surgical procedures in the world, in fact, it is the most frequent laparoscopic procedure performed. Over one million cholecystectomies are performed in the United States annually, with over 96% of those being performed laparoscopically[1].

It is common practice in most of the countries for anesthesia to be carried out with the use of the laryngeal mask airway (LMA), the most important and popular supraglottic airway device (SAD).

This device has several advantages when compared to tracheal intubation (TI), in particular avoidance of complications associated with TI, quick and ease of placement of the airway device itself, a lesser requirement for neuromuscular blockade, as well as a lower incidence of postoperative adverse events such as sore throat, dysphagia and dysphonia (based on its design to be a minimally stimulating to the airway)[2-4].

However, the use of the LMA in this context is controversial, the main concern being that it does not offer definitive airway protection from pulmonary aspiration of potential regurgitated gastric contents. The other controversial point is the ability of the LMA to provide correct ventilation in patients undergoing laparoscopic procedures. Laparoscopy is thought to increase the risk of aspiration due to the pneumoperitoneum-induced, which increase intra-abdominal pressure and it is accompanied by high peak airway pressure[5-7].

Therefore, many anesthesiologists advocate TI and mechanical ventilation for this kind of procedures.

When LMA is fully inserted using the recommended insertion technique, the distal tip of the cuff is at the upper esophageal sphincter, its sides face into the pyriform fossae and the upper border rests against the base of the tongue[8]. In this position, the LMA create an airway sealing, which permit a correct ventilation of the patient as well as a protection of airway against aspiration. We usually measure this sealing pressure or oropharyngeal leak pressure (OLP) in order to know how capable the LMA is to protect airway against potential aspiration of gastric contents. Different types of airway seal pressure tests can be performed using different test, it is commonly done by the anesthetist after general anesthesia induction for assessing OLP with the LMA prior to the beginning of the surgery[9].

The classical laryngeal mask airway (LMA-C) is the most widely studied SAD and in the last 15 years, several devices have been incorporated in order to improve the SAD's indications, these devices have bigger and better cuff, some of them with gastric access incorporation.

These designs offers a cuff that allows a higher seal pressure than the LMA-C and a drain tube that allows venting of the stomach contents and blind insertion of standard gastric tubes. Therefore, these new generation LMAs provides certain protection against regurgitation and prevents gastric insufflation when correctly placed.

These devices are a reasonable choice when performing anesthesia for procedures accompanied by high peak airway pressure, such as laparoscopy.

There are six SADs with a drain tube available in the market at this moment: Laryngeal Tube Suction™ (LTS or LTS-D if disposable), LMA Proseal™ (LMA-P), LMA Supreme™ (LMA-S), i-gel™ and recently the Guardian CPV™, the Baska Mask™ and the Ambu AuraGain™. LMA-P, LMA-S and i-gel are the most commonly used devices with gastric access in clinical anesthesia.

LMA was evaluated in laparoscopic cholecystectomy for the first time in 1996[10]. Between 2000 and 2002, a few studies reported the use of LMA-C and LMA-P for this kind of procedures[11-14]. Since 2010, several clinical studies have investigated the use of LMA with drain channel for laparoscopic cholecystectomy[2,15-19].

We will try to clarify if evidence-based medicine guides us to choose a LMA instead of an endotracheal tube (ETT) when performing a general anesthesia for laparoscopic cholecystectomy. And also what is the most appropriate airway device for this laparoscopic procedure. This review is an approach based on defining a specific and clinically relevant question, followed by a systematic search for evidence about the appraised topic.

Table 1 Summary of the studies investigating ventilation and aspiration with the laryngeal mask airway

Ref.	Group	*n*	Ventila-tory efficiency (%)	No. of insertion attempt ($1^{st}/2^{nd}/3^{rd}$)	Airway insertion time (*s*)	OLP (cm H_2O)	Peak airway pressure before pneumoperi-toneum (cm H_2O)	Peak airway pressure after pneumoperi-toneum (cm H_2O)	Blood on mask (%)
Lu *et al*[12], 2002	LMA-P	40	100	33/7/0	-	29 ± 6	18.3 ± 3	24.1 ± 2	15
	LMA-C	40	80	40/0/0	-	19 ± 4	17.6 ± 2	22.7 ± 3	
Maltby *et al*[13], 2002	LMA-P	50	92	-	-	34 ± 4	18 ± 5	25 ± 5	-
Sharma *et al*[15], 2010	LMA-P	30	100	24/5/1	14.2 ± 5.5	38.9 ± 3.2	15.9 ± 3.2	21.5 ± 3.2	26.6
	i-gel	30	100	28/2/0	13.6 ± 4.2	35.6 ± 4.8	14.9 ± 2.9	20 ± 3.7	10
Beleña *et al*[16], 2011	LMA-S	100	100	91/0/0	12 ± 4.6	28.8 ± 5.2	17.5 ± 3.3	22.9 ± 1	0
Hoşten *et al*[17], 2012	LMA-P	29	100	27/2/0	15.6 ± 6	27 ± 4.7	-	-	6.8
	LMA-S	30	100	28/2/0	12.5 ± 6	27 ± 2.9			3.3
Beleña *et al*[18], 2013	LMA-P	60	100	51/9/0	11.2 ± 4	30.7 ± 6	19 ± 3	26 ± 5	3.3
	LMA-S	60	100	55/5/0	11.8 ± 2	26.8 ± 4	18 ± 4	24 ± 4	0

Values are presented as numbers, mean ± SD, numbers or percentage. LMA-C: Laryngeal mask airway classic; LMA-P: Laryngeal mask airway Proseal; LMA-S: Laryngeal mask airway Supreme; OLP: Oropharyngeal leak pressure.

LITERATURE SEARCH QUESTION

The search question was clarified to "In healthy patients with no risk factors for regurgitation, undergoing elective laparoscopic cholecystectomy, does the use of the LMA in preference to tracheal intubation provide inadequate ventilation or increase the risk of pulmonary aspiration?"

Search methods

The ideal study design to answer this question is a randomized, controlled trial that compares ventilatory efficacy and the incidence of aspiration between LMA and tracheal intubation in patients undergoing laparoscopic cholecystectomy. We did not limit this search to those articles dealing with ventilatory efficacy and the incidence of aspiration, but we included all studies about LMA for laparoscopic cholecystectomy. A search was performed in MEDLINE, EMBASE, CENTRAL and Google Scholar in November 2014, and updated in February 2015. Search terms used in various combinations were: "laryngeal mask airway", "LMA", "laparoscopic cholecystectomy" and "laparoscopy".

All studies that met these criteria were included regardless of publication language. Review articles, case reports, case-series, letters to the editor, commentaries, proceedings, laboratory science studies, comparative studies using manikins, and any other non-relevant studies were excluded.

Summary of findings

The search identified ten randomized controlled trials, case series and large prospective observational studies (Table 1).

There was no meta-analysis on the specific subject of our appraised topic but a meta-analysis of trials, other studies and cases reporting the use of the LMA, involving 706 patients, reported optimal ventilation in 99.5% of the patients and no aspiration was identified[2,11-19]. The vast majority of the patients were successfully ventilated through the assigned laryngeal mask [LMA-C (n = 120), LMA-P (n = 306), LMA-S (n = 250), i-gel (n = 30)]. We excluded 62 patients ventilated with the streamlined liner of the pharynx airway (SLIPA™), because this SAD is not really considered a LMA[19].

Four of 16 obese LMA-P patients (BMI > 30 kg/m^2) crossed over to ETT because of respiratory obstruction or airway leak (0.5%)[13]. In 3 patients treated with LMA-C, ventilation failed but was subsequently optimal with the LMA-P[12].

Sharma *et al*[15] reported only 3 cases of regurgitation in patients ventilated with LMA-P, although no cases of aspiration were recorded. No more cases or regurgitation nor aspiration were found among the 706 patients studied.

Most of the studies analyzing and comparing the use of LMA in laparoscopy have focused on gynecological patients. Therefore, most part of LMA data were derived from gynecological laparoscopic procedures[5,20-39]. These data are not comparable with ours because gynecological laparoscopic has some differences when compared to cholecystectomy, such as higher intra-abdominal pneumoperitoneum pressure, trendelenburg position and all patients are women.

Other studies included different types of laparoscopic procedures apart from cholecystectomy (gynecological, appendicectomy or nephrectomy) and they were also excluded from our analysis[10,40,41]. We only found two studies involving the use of LMA for pediatric laparoscopic procedures and they were as well excluded[42,43].

Maltby *et al*[11] studied 101 adult American society of anesthesiologists (ASA) 1-2 patients scheduled for elective laparoscopic cholecystectomy using LMA-Classic or ETT, focused on gastric distension and ventilation parameters. They concluded that positive pressure ventilation with LMA-C of permitted adequate pulmonary ventilation and gastric distension occurred with equal frequency with either airway device. These authors, conducted another similar study in 2002[13] comparing LMA-P with ETT. They included 109 patients stratifying

them as non-obese or obese (BMI > 30 kg/m^2) and stated that LMA-P provided a correct ventilation without clinically significant gastric distension in all non-obese patients. Four of 16 obese LMA-P patients crossed over to TI because of failed ventilation, so the recommended that further studies were required to determine the use of the LMA-P for laparoscopic cholecystectomy in obese patients.

The third study, conducted by Lu *et al*[12], tested the hypothesis that the LMA-P was a more effective ventilatory device than LMA-C for laparoscopic cholecystectomy in 80 ASA 1-2 patients. Ease of insertion, efficacy of seal, peak airway pressures and oxygenation were recorded. These authors determined that LMA-P was a more effective ventilatory device for laparoscopic cholecystectomy than the LMA-C. Although first-time insertion success rates were higher for the LMA-C, OLP was higher for the LMA-P and ventilation was suboptimal less frequently with the LMA-P under pneumoperitoneum condition. In 3 patients receiving LMA-C, ventilation failed but was subsequently optimal using the LMA-P.

This is an important work, because it was the first one considering that LMA-P is a better device than LMA-C for laparoscopy and they did not recommend the use of the LMA-C for laparoscopic cholecystectomy.

Natalini *et al*[14], compared the frequency of airway seal and sore throat with the LMA-P and the LMA-C in a study involving 60 ASA 1-3 patients for laparoscopic cholecystectomy. Patients were ventilated adding positive end-expiratory pressure 10 cm H_2O through the proseal or the standard LMA, in order to improve ventilation. Both devices showed similar ventilatory efficiency during laparoscopy. The sore throat evaluation performed in recovery room was scored as mild and there were no differences between the groups.

The fifth research, involved 60 patients and compared respiratory mechanics in laparoscopic cholecystectomy using LMA-P and i-gel[15]. They observed that OLP was higher in LMA-P group, however, dynamic compliance was higher with the i-gel. They performed a fibreoptic evaluation of positioning of the devices, showing a higher malrotation for i-gel. Although regurgitation occurred in 3 cases (LMA-P), aspiration was not reported. Both devices provided optimal ventilation and oxygenation.

Another prospective observational study was performed in 100 patients undergoing laparoscopic cholecystectomy with LMA-S[16]. This device was successful inserted in all patients (first attempt *n* = 91 and second attempt *n* = 9) and mechanical ventilation was adequate in all cases. Gastric tube insertion was successful in all patients and graded as easy in 97% of the cases. Mean OLP was 28.8 cm H_2O (± 5.2; range 18-40 cm H_2O) and median (range) of stomach size on entry of the laparoscope, and change in stomach size during surgery (scored by the surgeon on an ordinal scale of 0-10) did not interfere with the procedure in any patient. The study concluded that supreme is an easy to insert and effective ventilatory device for laparoscopic cholecystectomy that provided an optimum airway seal with minimum adverse events.

A prospective randomized study conducted in 2012[17], compared the safety and efficacy of supreme and proseal during laparoscopic cholecystectomy. LMA-S was easier device to insert, as well as its drainage tube which was more quickly inserted. Seal pressure was similar in both groups and they did not find differences regarding the degree of gastric distension. Therefore, the study stated that both devices provided optimal ventilation and LMA-S is a good alternative to LMA-P for laparoscopy in suitable patients and experienced users.

The next publicated study was conducted at Sureste University Hospital in Madrid (Spain)[18] and it is the largest comparison performed between two LMA for laparoscopic cholecystectomy. This prospective randomized single-blind study, tested the efficacy and safety of the LMA supreme *vs* the LMA proseal in 120, ASA 1-3 patients undergoing elective laparoscopic cholecystectomy. These authors found that the LMA-S has a lower OLP and achieves a lower maximum tidal volume compared to the LMA-P. The success rate of the first attempt insertion was higher for the LMA-S group and this could have important implications when using the LMAS as an airway rescue device. The easy of insertion of the drain tube, adequacy of ventilation and complication rates are comparable for the two airway devices.

Aydogmus *et al*[2], studied a small sample of 60 patients wondering if LMA-S can be an alternative to endotracheal intubation in laparoscopic surgery. They focused on ventilation efficacy, ease of insertion, hemodynamic response (heart rate and mean arterial blood pressure) during insertion and removal of the mask and postoperative adverse events. In the end, they concluded that this device can be a suitable alternative to intubation for laparoscopy in selected patients.

Our last selected article, compared the quantitative clinical performances of the SLIPA and the LMA proseal regarding intensity of gastric distension in 124 anesthetized and paralyzed patients undergoing laparoscopic cholecystectomy. Secondary outcomes were the fiberoptic bronchoscopic view of the glottis, the severity of blood stain, and postoperative sore throat. There were no statistically significant differences between groups for each of these parameters[19].

DISCUSSION

In summary, in our review involving 706 patients undergoing laparoscopic cholecystectomy, ventilation was optimal in almost all the cases (99.5%) and it only failed in 4 obese patients (in the other 3 patients it was not considered as a failure because it was solved using another kind of LMA), which underlines the importance of a good selection of the patients. As showed in this review, the use of LMAs (particularly those LMA with gastric access) for these laparoscopic procedures

provided an adequate tidal volume and it was consistent with an optimal ventilation and oxygenation. Moreover, most of the studies performed with LMA involving gynecological laparoscopy or other kind of surgical procedures, permitted adequate ventilation in nearly 100% of the patients.

The studies reviewed also included capnography measurement during surgery as an important parameter to control hypercapnia in laparoscopic procedures. Mean $EtCO_2$ was maintained between 30-36 mmHg and it always remained < 45 mmHg[12-18].

These studies suggested a safe pneumoperitoneum pressure even using a relatively high peritoneal insufflation pressure of 15 mmHg used in the early studies[12,13]. Recent articles also found safe pressure when using lower values of 12-13 mmHg[16-18].

Regarding the risk of aspiration when using a LMA for general anesthesia during laparoscopic cholecystectomy, we observed a very low incidence of regurgitation and aspiration. This review found only 3 cases of regurgitation out of 706 patients studied (0.4%) and no cases of pulmonary aspiration were reported. Our results coincide with other authors; the largest study ever performed using LMA conducted by Chandi Verghese and Joseph Brimacombe[10] in 11910 patients for conventional and nonconventional usage, including 1534 laparoscopies (1469 gynecological and 65 cholecystectomies), only found four cases of regurgitation and one aspiration case. This patient was a female undergoing spontaneous ventilation anesthesia for an elective non-laparoscopic surgery who aspirated gastric contents during the procedure. She experienced an initial adverse outcome but with full recovery. These authors used LMA-C, because at that time, LMA with gastric access had not been introduced yet.

Brimacombe[44], stated that the LMA-C was used in 3000 selected women undergoing gynecological laparoscopy without serious morbidity. This suggests that the true risk of aspiration is likely to be less than 1 in 1000 (using 3/n to estimate the upper limit of a 95%CI).

Finally, a meta-analysis by Brimacombe and Berry[45] in 1995 about the incidence of aspiration associated with the LMA, involving 12901 patients, gave a final incidence of 2 aspiration in 10000 and case reports showed that most cases has one or more predisposing factors.

These three articles stated a very low incidence of aspiration over large series of patients when using the classic LMA (this device has not gastric access). We must have into account that, our review was performed over a sample mostly constituted by LMA with drain channel and this device is more appropriate for nonconventional usage such as laparoscopy than LMA-C. Based on the characteristics of these devices, its better airway seal pressure and the incorporation of a gastric access that allows the insertion of a gastric tube and the aspiration of gastric contents if necessary, makes this masks the optimal device to use for laparoscopic cholecystectomy.

The presence of gastric drainage channel should be mandatory for these procedures, because a common situation is the need for aspiration of gastric contents (including air) in order to properly expose the surgical field (gastric distention may impair the exposure of the triangle of Calot).

CONCLUSION

The published evidence does not allow us to totally answer the question we posed for this appraised topic. On the one hand, mechanical ventilation has been proved to be adequate when using LMA for laparoscopic cholecystectomy in selected patients. Although we do not recommend the use of the classic LMA for these procedures, only LMA with gastric access are advised. We do not either recommend the use of any type of LMA in laparoscopy for spontaneously breathing patients.

On the other hand, there is limited evidence to support the use of the LMA for laparoscopy. In particular, it is not completely clarified that the use of the LMA is not associated with an increased risk of pulmonary aspiration. We found, however, that the reported incidence of aspiration associated with the use of the LMA in laparoscopic surgery is very low. Moreover, we have found a non-existent incidence of aspiration when using LMA with drain channel for laparoscopic cholecystectomy in selected patients.

Based on our findings, we suggest the following inclusion criteria for using LMA in laparoscopic cholecystectomy: ASA 1-3 patients scheduled for elective laparoscopic cholecystectomy, non-obese patients (BMI < 30 kg/m^2), pneumoperitoneum pressure value lower than 13 mmHg, always using a LMA with drain channel and maybe performing a prophylactic routine gastric aspiration in order to minimize the risk of regurgitation and properly expose the surgical field.

Future research should focus on actual adverse outcomes and morbidity of these devices. A randomized comparison of tracheal intubation and LMA, investigating the risk of aspiration laparoscopy (assuming an incidence of 1 in 1000), would require a sample size of more than 30000 to find a twofold increase in risk. Such a trial is not feasible, but every year, hundreds of patients are successfully anesthetized using these devices with no morbidity. Clinical practice and the performance of more studies could provide satisfactory evidence in the future for anesthesiologists and patients.

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