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## Airway management during gynaecological laparoscopy – is it safe to use the laryngeal mask airway?

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The safety of anaesthesia for gynaecological laparoscopy probably depends largely on short operative time, close intraoperative monitoring and the experience of both anaesthetist and surgeon. However, there is debate over the most suitable mode of ventilation and form of airway management. It is argued that hypoventilation and the risk of regurgitation make intubation and ventilation mandatory, and yet spontaneous ventilation with a facemask appears to be a safe technique with reduced minor morbidity. The laryngeal mask airway (LMA) has added a new dimension to the debate since it offers potential advantages over both the tracheal tube and the facemask. The aim of this review is to analyse the physiological and clinical evidence supporting the mode of ventilation and airway management during gynaecological laparoscopy and to discuss these issues in the context of the LMA. We conclude that the physiological and clinical data available to determine the suitability of the LMA is inadequate. Further proof is required before widespread adoption of these techniques. It is possible that advances in LMA design may extend the suitability of the LMA for gynaecological laparoscopy.

Key words: Equipment, laryngeal mask, gynaecological laparoscopy, complications

### Introduction

Laparoscopy was first described in 1912<sup>1</sup>; however the technique was virtually unknown until the mid-1960s when lighting techniques and optical systems improved sufficiently to construct suitable equipment<sup>2</sup>. As the new surgical technique gained momentum, the problems of anaesthesia in the presence of tension pneumoperitoneum emerged. Early laparoscopic studies reported lengthy procedures and the use of large volumes of gas to produce a pneumoperitoneum<sup>3</sup>. Patients were considered to be at significant risk of aspiration and hypoventilation. Intubation and positive pressure ventilation were widely recommended<sup>3-6</sup>, a view supported by the Royal College of Obstetricians and Gynaecologists<sup>7</sup>. Surgeons subsequently developed greater speed and expertise and aimed to complete the procedure within 10 min and with minimal tilt<sup>8</sup>. The necessity for tracheal intubation fell into doubt when considering the risks of increased minor morbidity in the day surgery situation<sup>9,10</sup>.

Thirty years after laparoscopy became established, uncertainty remains over the most suitable mode of ventilation and form of airway management. The intro-

duction of the laryngeal mask airway (LMA) into clinical practice has added a new dimension to the debate since it offers potential advantages over both the tracheal tube and the facemask. The aim of this review is to analyse the physiological and clinical evidence supporting the mode of ventilation and airway management during gynaecological laparoscopy, and to discuss these issues in the context of the LMA.

### Physiological changes during laparoscopy

#### *Cardiovascular system*

Tension pneumoperitoneum has a complex effect on the cardiovascular system and is influenced by several factors including the degree of Trendelenburg tilt, the intra-abdominal pressure and the ventilation technique. Blood is shunted out of abdominal organs and the inferior vena cava into central and peripheral venous reservoirs. The net effect is a minimal alteration in cardiac output with intra-abdominal pressures of 15–20 cm H<sub>2</sub>O in healthy young females<sup>11</sup>. As pressures rise above 20–25 cm H<sub>2</sub>O, however, there is marked compression of the inferior vena cava, reduced venous return and a consequent reduction in cardiac output. This fall in cardiac output leads to reflex sympathetic compensation increasing myocardial contractility, heart rate and systemic vascular resistance. The effect is made more

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complex by other patient factors such as age, volume of CO<sub>2</sub> absorbed, intravascular volume status, associated cardiac disease and the effects of administered anaesthetic agents.

Hypercarbia may lead to an increase in dysrhythmias, particularly during halothane anaesthesia when they may occur in up to 27% of patients<sup>12</sup>. However, this will usually be of little clinical significance. It has been shown that spontaneous ventilation (SV) using a facemask does not lead to significant dysrhythmia during isoflurane anaesthesia<sup>13</sup>.

#### *Respiratory system*

There is a reduction in vital capacity which is influenced by the patient's age, weight, preoperative lung function, degree of head-down tilt, administered anaesthetic agents and intraoperative ventilation techniques. Kenefick et al. have shown that spontaneous breathing through a facemask is associated with a modest hypercarbia but no acidosis or dysrhythmia during isoflurane anaesthesia<sup>13</sup>. Desmond and Gordon showed an increase in minute volume and respiratory acidosis caused by the steep Trendelenburg position and the pneumoperitoneum-induced splinting of the diaphragm during halothane anaesthesia<sup>3</sup>. Airway problems have been reported in 23% of patients breathing spontaneously through a facemask during laparoscopy<sup>10</sup>.

#### *Gastrointestinal system*

The association of laparoscopy with increased risk of regurgitation of gastric contents is related to the lithotomy position, head down tilt, the surgeon pressing on the abdomen and insufflation of the peritoneal cavity<sup>14</sup>. Other possible causes of regurgitation are stimulation of the peritoneum<sup>15,16</sup>, airway obstruction<sup>17,18</sup> and hiccup<sup>19</sup>. Epidemiological evidence from large series report a very low incidence of aspiration during laparoscopy. The Royal College of Obstetricians and Gynaecologists reported no aspiration events and one episode of regurgitation from 50 048 patients of whom an estimated 10% were managed with a facemask and the remaining 90% with a tracheal tube<sup>7,20</sup>. Wong reported 15 000 facemask anaesthetics<sup>21</sup> and Scott 2000<sup>22</sup> with no aspiration events.

However, there is a paucity of data regarding the incidence of regurgitation during laparoscopy and how it is influenced by tilt, intra-abdominal pressure, mode of ventilation and airway type. Duffy measured pharyngeal pH during laparoscopy and reported a 2.2% (2 : 93) incidence of regurgitation in intubated ventilated patients. Patients were placed in steep Trendelenburg tilt and given atropine, which may have interfered per se with the lower oesophageal sphincter<sup>23,24</sup>. Carlsson and Islander using a similar technique showed that regurgitation occurred in 20% of emergency laparoscopies<sup>25</sup>. Presumably this high incidence was related to the fasting status. Kurer and Welch reported no episodes of regurgitation in 120 patients,

50% of whom were managed with the facemask and spontaneous ventilation<sup>10</sup>.

Gastroenterologists now focus on the lower oesophageal sphincter (LOS) as the major anti-reflux barrier, after finding that only manoeuvres that restore LOS competence are effective in symptomatic relief<sup>26</sup>. It is likely that the LOS plays an important role in preventing regurgitation during laparoscopy. The importance of the LOS in preventing regurgitation was illustrated by Valdwogel et al. who reported a 52% incidence of regurgitation via or around a gastric tube placed during laparoscopy in 226 women<sup>27</sup>. Jones et al. showed that the LOS is capable of rapid adaptive responses to changes in intragastric pressure during laparoscopy with maximum intraperitoneal pressures of 30 cm H<sub>2</sub>O and a 10-15° head-down tilt, and that barrier pressure is increased or maintained<sup>28</sup>. Roberts and Goodman reported no episodes of reflux, as determined by an oesophageal pH probe, in 63 women undergoing gynaecological laparoscopy<sup>19</sup>. They suggested that insufflation may also flatten the intra-abdominal oesophagus, adding to the overall barrier pressure of the sphincter. Raised intra-abdominal pressure and Trendelenburg tilt does not therefore necessarily increase the risk of regurgitation<sup>28</sup>. However, Sloan et al. recently showed that in the presence of raised intra-abdominal pressure, the lower oesophageal pressure may be compromised to an extent that is clinically relevant<sup>29</sup>.

#### **The laryngeal mask airway**

The LMA was designed by Brain in 1981 following anatomical studies of the upper airway in human cadavers<sup>30</sup>. Interestingly, the first published paper included 16 patients undergoing gynaecological laparoscopy without problems<sup>31</sup>. The LMA evolved from the search for an airway that was more practical than the facemask and less invasive than the tracheal tube. When correctly placed, the cuff portion sits in the hypopharynx at the interface between the gastro-intestinal and respiratory tracts, where it forms a circumferential low pressure seal around the glottis, thus enabling conditions suitable for controlling ventilation. This has advantages in terms of improving gas flow through the upper airway<sup>32,33</sup> and allowing direct access to the glottis without loss of airway control when compared to currently available oral airways. It also avoids invasion of the larynx and oesophagus<sup>34</sup>.

Advantages over the facemask include provision of a clearer airway with improved oxygenation and a lower incidence of airway obstruction events whilst freeing the operators hands. Advantages over the tracheal tube include independence from the need to visualize directly the larynx and to produce 100% muscle relaxation, less invasion of the respiratory tract, avoidance of the risks of endobronchial or oesophageal intubation and less trauma to local tissues. Disadvantages are that the LMA does not protect the lungs from regurgitated gastric contents and is not suitable for high airway pres-

sure ventilation. Over the past 6 yr since its development, the LMA has become widely accepted worldwide as a general purpose airway with a good safety record. The majority of reviews<sup>35–40</sup> and editorials<sup>41–45</sup> consider that it has an important place in anaesthetic practice. The principal use of the LMA is in elective surgery, but it also has a role in the management of difficult intubation both as a substitute airway and as an aid to intubation<sup>46</sup>. To date, the LMA has been the subject of over 850 publications and has been used in at least 20 million anaesthetised patients<sup>41</sup>.

#### *Cardiovascular system*

Laryngoscopy and subsequent tracheal intubation is associated with a 25–50% rise in blood pressure, and a similar increase in heart rate<sup>47</sup>. The potentially harmful effects of the acute haemodynamic stress response to conventional intubation have been well described<sup>48,49</sup>. Insertion of the LMA is associated with only a 0–20% rise in blood pressure and heart rate in both adults and children<sup>50–55</sup>. This is comparable to the facemask and Guedel airway and can be related to the avoidance of anterior structures on insertion and the lack of instrumentation of the larynx<sup>52</sup>. Plasma concentrations of adrenalin and noradrenalin are higher following tracheal intubation than LMA insertion<sup>56</sup>. Once *in situ*, it occupies a relatively afferent nerve deficient area around the glottis that is well adapted to dealing with foreign bodies such as boluses of food. Patients with an LMA require significantly less anaesthetic agent to maintain depth of anaesthesia than those who are intubated<sup>57</sup> and have less hypertension during emergence<sup>58</sup>. This benefit may extend into the postoperative period with a reduced requirement for postoperative analgesia during recovery<sup>59</sup>. The cardiovascular effects of general anaesthetic agents, usually hypotension and the potential for dysrhythmias, will by inference also be reduced when the LMA is used. This cardiovascular advantage of the LMA probably has little clinical significance for young, healthy women undergoing laparoscopy.

#### *Respiratory system*

Ventilation via the LMA is an effective and established technique with a good safety record and can be readily achieved during laparoscopy. Devitt et al. demonstrated that ventilation through the LMA is adequate at ventilation pressures varying from 15–30 cm H<sub>2</sub>O and is comparable to tracheal tube ventilation<sup>60</sup>. The high incidence of leak in the study may be related to use of inadequately sized LMAs. Berry and Verghese reported no leaks with tidal volumes of 10 ml kg<sup>-1</sup><sup>61</sup>, using the size 4 LMA in all normal sized adults. Van Damme assessed leak pressures in 4866 patients and showed that leak pressure of <15 cm H<sub>2</sub>O occurred in only 2.7%<sup>62</sup>. Haden et al. reported using the LMA/intraoperative positive pressure ventilation (LMA/IPPV) technique on 593 occasions with only two significant clinical problems

(0.3%)<sup>63</sup>. Over the same period there were three serious problems with the Trendelenburg tilt/intraoperative positive pressure ventilation [(TT/IPPV) (TT = tracheal tube)] technique in 187 uses (1.6%). The use of the LMA with IPPV has been enhanced by development of the size 5 for larger adult patients<sup>64</sup>.

The safe use of the LMA for controlled ventilation is further illustrated by Verghese et al.'s prospective survey of 2359 LMA anaesthetics in which 41% underwent controlled ventilation and there were no cases of aspiration<sup>65</sup>. This study has now been extended to over 11 000 patients, more than 4900 of whom underwent IPPV, with a similar absence of morbidity<sup>66</sup>. Approximately 10% of patients in Verghese's studies underwent gynaecological laparoscopy. Looking more broadly at the LMA literature, a meta-analysis of 547 LMA publications failed to show any link between IPPV and aspiration either in patients included in LMA studies ( $n = 12\,900$ ) or aspiration case reports ( $n = 10$ )<sup>67</sup>.

#### *Gastrointestinal system*

Epidemiological studies indicate that the incidence of regurgitation and subsequent aspiration with the LMA is similar to that with the facemask and also the tracheal tube. A meta-analysis of published literature on the LMA to September 1993 calculated that the overall incidence of pulmonary aspiration was in the region of 2 : 10 000<sup>67</sup>. More recently large scale epidemiological studies have confirmed these figures. Haden et al. reported a figure of 1 : 3500<sup>68</sup>, Van Damme 0 : 5000<sup>62</sup>, Braun and Fritz 1 : 3000 (paediatric)<sup>69</sup> and Verghese et al. 1 : 11 910<sup>66</sup>. This compares favourably with large pre-LMA epidemiological studies have documented low incidences of perioperative pulmonary aspiration in both adults and children<sup>70,71</sup>.

It has been suggested that reflex relaxation of the upper and lower oesophageal sphincters may be activated once the LMA cuff is inflated in the pharynx. The major implication is that such activity may predispose to regurgitation and aspiration in low risk patients, a potential cause of morbidity and mortality<sup>15,72</sup>. Work conducted in the 1950s demonstrated that sustained distension of the pharynx induced prolonged relaxation of the LOS<sup>73</sup>. There is some evidence from dye studies<sup>74,75</sup>, one study using a pressure probe pull-through technique<sup>76</sup> and one using an oesophageal pH probe<sup>77</sup> that LOS tone may be reduced when compared to the facemask<sup>74–76</sup> or tracheal tube<sup>77</sup>. Valentine et al. compared lower oesophageal pH changes in patients managed with either the LMA or tracheal tube during IPPV. They showed a high incidence of regurgitation with the LMA during emergence, but the pH drop was small and above the commonly accepted value of 2.5<sup>77</sup>. This may have been related to poor timing of reversal agent or inadequate LMA size selection<sup>78</sup>. However, this theory remains controversial<sup>79,80</sup> and repeat dye<sup>81,82</sup> and oropharyngeal pH studies in both ventilated<sup>83</sup> and spontaneously breathing patients<sup>84</sup> have failed to

confirm these findings. The variable figures found in the different studies may simply reflect the sensitivities of the detection techniques.

It is also possible that the upper oesophageal sphincter (UOS) may assist in prevention of regurgitation of oesophageal contents during light general anaesthesia in the absence of neuromuscular blockade<sup>16</sup>. The presence of a mass above the UOS does not cause it to relax<sup>85</sup> and the mechanical features controlling the UOS are largely unknown. Vanner et al. showed that during spontaneous ventilation (SV) with no muscle relaxant, the UOS pressure does not fall significantly with an LMA in situ<sup>86</sup>. In comparison, non-LMA related manoeuvres such as laryngoscopy and introduction of a gastric tube through the UOS could lead to regurgitation<sup>87,88</sup>.

### Laparoscopy and the LMA

Laparoscopy is one of the most common surgical procedures and a postal survey of consultants employed by the South East Thames Regional Health Authority revealed that approximately 40% used the LMA for gynaecological laparoscopy<sup>89</sup>. Considering the large numbers of patients and the fact that recommendations already exist to intubate and ventilate<sup>7</sup>, there is a remarkable lack of data demonstrating its efficacy and safety. Published trials are limited in terms of patient numbers and method of assessment of regurgitation, but they support the LMA as a safe technique both for spontaneous and controlled ventilation<sup>90,91</sup>.

Goodwin et al. studied 40 women undergoing laparoscopy using the LMA and SV with either total intravenous anaesthesia (propofol) or inhalational anaesthesia (enflurane) and found no clinically significant cardiorespiratory differences between the two techniques<sup>90</sup>. There were no episodes of aspiration and no perioperative dysrhythmias. Procedures lasted approximately 15 min. Swann et al. compared controlled ventilation with the tracheal tube vs. either controlled or spontaneous ventilation via the LMA in 60 patients<sup>91</sup>. There were no clinically significant differences in the intraoperative conditions of the two groups, although the procedure was quicker with the LMA, with operation times averaging 10.5 min. There were no episodes of regurgitation. The incidence of dysrhythmias was low in both groups, but there was a reduced sympathetic response to LMA insertion. There were no differences in minor morbidity between the groups. No data was provided about intra-abdominal pressure or degree of tilt in either study.

The results of large-scale epidemiological studies have recently become available and support the findings of controlled trials. Malins et al. used the LMA in 3000 laparoscopy patients without producing major complications<sup>92,93</sup>. Verghese et al. reported its use in 1600 laparoscopy patients of whom 70% received anaesthesia through the LMA. No aspiration, regurgitation or cardiac events occurred<sup>66</sup>.

There has been, however, one published report of

**Table 1.** Suggested guidelines for use of the LMA during laparoscopy

- 1 Experienced LMA user
- 2 Meticulous selection of patients – fasted, no history of oesophageal reflux, normal lung compliance
- 3 Surgeon aware that the LMA is being used?
- 4 Select correct size of LMA: size 4 >50 kg
- 5 Insert the LMA when anaesthetic depth is adequate ± muscle relaxation (mivacurium, rocuronium suitable)
- 6 Use standard insertion technique to achieve optimal placement of the LMA
- 7 Either SV or IPPV – use tidal volume 8–10 ml kg<sup>-1</sup>
- 8 Either total intravenous anaesthesia or volatile agent – avoid halothane
- 9 Adhere to '15' rule: <15° tilt; <15 cm H<sub>2</sub>O IAP; <15 min duration
- 10 Avoid inadequate anaesthesia or muscle relaxation during surgery
- 11 Reverse muscle relaxant prior to termination of general anaesthesia
- 12 Avoid disturbance of the patient during emergence

IAP: Intra-abdominal pressure.

pulmonary aspiration in a patient who underwent elective laparoscopic sterilization with an IPPV technique<sup>94</sup>. The true, unreported incidence of regurgitation is unknown and anecdotal. More significantly, 1:16 patients undergoing laparoscopy using the LMA/IPPV technique regurgitated dye into the pharynx, although aspiration did not occur<sup>92</sup>.

### Conclusion

The safety of anaesthesia for gynaecological laparoscopy probably depends largely on short operative time, close intraoperative monitoring and the experience of both anaesthetist and surgeon<sup>10</sup>. Regardless of the concerns of sore throat and incomplete reversal of muscle relaxant, the aim of anaesthesia for laparoscopy must be to minimize the risk of aspiration and life-threatening dysrhythmias. Proving that a technique meets these criteria is logistically difficult and further larger studies, comparing the LMA with the tracheal tube and facemask, are required to better indicate the degree of tilt, the duration of procedure and patient type for which the technique may be regarded as reasonably 'safe'. The physiological and clinical data available to determine the suitability of the LMA is inadequate, but it would seem that there are reasonable grounds for experienced clinicians to use the LMA provided certain guidelines are considered (Table 1). Further proof is required before widespread adoption of these techniques. Finally, it is possible that advances in LMA design may extend the suitability of the LMA for gynaecological laparoscopy<sup>95</sup>.

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