Prone surgery and laryngeal mask airways: an overview of recent studies and personal experience

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Abstract

Prone surgery is traditionally performed using endotracheal intubation in the supine position, followed by positioning of the patient in the prone position. This method exposes the patient to the disadvantages of neuromuscular blocking agents which can become problematic for short cases. Positioning of the patient in the prone position also involves a variety of complications. Clinicians tend to avoid the use of a laryngeal mask airway (LMA) in the prone position, but several trials demonstrate its low rate of complication if patient selection is performed properly. Obesity is also demonstrated not to be a contraindication to this anaesthetic technique. Patients are more haemodynamically stable if induced in the prone position using an LMA rather than supine induction, followed by an endotracheal tube. Although no trial has demonstrated its safety over that of endotracheal intubation, it appears to be a safe alternative to the traditional technique.

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Introduction

Prone surgery is traditionally undertaken following induction in the supine position, followed by endotracheal intubation. The patient is then positioned appropriately in the prone position once the airway has been secured.

This technique has been scrutinised for several reasons:

- Endotracheal intubation is associated with complications, e.g. a sore throat, endobronchial intubation, airway trauma, and difficult or impossible intubation.
- Endotracheal intubation may require the use of neuromuscular blocking drugs with their own risks and side-effect profiles.
- Patients intubated in the supine position require very careful airway management while positioning the patient in the prone position to avoid tube displacement or patient trauma.
- Effective laryngeal mask airway (LMA) placement in the prone position may suggest a rescue airway in the event of endotracheal extubation during prone surgery.
- Certain procedures are of such a short duration that the use of a non-depolarising neuromuscular blocker to facilitate endotracheal intubation is impractical. On the contrary, succinylcholine also has a wide range of side-effects, despite its short duration of action. Alternatively, the use of high-dose propofol and opiates to facilitate endotracheal intubation may lead to a greater incidence of pharmacological side-effects, e.g. severe hypotension or bradycardia.

Insertion of the LMA in the prone position is not a novel idea, and has been researched using the LMA Classic™, reinforced LMA, LMA Proseal™, and most recently, LMA Supreme™.

Relevant trials

A PubMed search was conducted using the search parameters “prone”, “LMA” and “laryngeal mask airway”. The dates of the trials were limited to 2000-2013. Twenty-one trials were identified and narrowed down to seven, once cases involving paediatrics or other non-relevant topics were excluded.

The use of LMAs for prone surgery appears to have originated in situations of unintended extubation of a patient during surgery, or during situations of airway rescue. Brimacombe and Keller[1] described an example of a morbidly obese patient with a difficult airway scheduled

for major back surgery who was intubated with the aid of a gum-elastic bougie. The patient was accidentally extubated during the procedure. A gum-elastic bougie was railroaded over the improperly situated endotracheal tube and an LMA Proseal™ was railroaded over the bougie. A gastric tube was inserted through the provided port on the LMA, and the procedure was completed uneventfully with the LMA in situ.

LMAs have also been used when patient positioning presented with difficulties, making endotracheal intubation difficult or dangerous. Valero et al[2] described a case in which a patient presented after a work-related injury with a drill bit protruding from the posterior spinal area at the level of C1-C2. The patient presented with neurological fallout, and it was feared that intubating the patient in the supine position would worsen his injury.

The patient was anaesthetised in the prone position using 8% sevoflurane and 0.7 mg intravenous atropine. Muscle relaxants were avoided as muscle tone was considered to play a role in maintaining the position of the drill bit. A size 4 LMA was inserted, and the position confirmed with a flexible fibre-optic bronchoscope.

Anaesthesia was maintained using sevoflurane, oxygen and intravenous fentanyl. The patient was fully ventilated. The drill bit was removed, exposing a vertebral artery tear that was surgically controlled and repaired. The patient emerged in the recovery room with mild neurological fallout that gradually disappeared over the next few hours.

The LMA Supreme™ may be suitable for prone surgery for the following reasons:[3]

- The LMA is reinforced.
- It follows the anatomical shape of the airway.
- It provides a port for access to gastric fluid.
- It avoids the abovementioned problems pertaining to endotracheal intubation.

Table I shows a comparison of the results found in the relevant trials using the different devices.

Various patient-positioning techniques used in the trials are highlighted in Table II.

Patients were usually positioned prior to induction, although on occasion[3] they were provided with a choice of supine or prone induction. Prone positioning prior to induction allows the patient to find a position of comfort on the operating

Table I: Comparison of the relevant trials

References	Sharma, Verghese and McKenna[3]	Lopez, Valero and Brimacombe[4]	Ng, Raitt and Smith[5]	Thomas, Bhorkar, D'Silva and Chilqar[6]	Weksler et al[7]
Patients	**205**	**40**	**73**	**74**	**50**
Device	**LMA Supreme™**	**LMA Supreme™**	**LMA Classic™**	**LMA Supreme™**	**LMA Classic™**
ASA class	**I/II/III**	**I/II**	**I/II**	**I/II**	**I/II**
Excluded	• GORD • BMI > 55 kg/m^2 • Pregnancy • Paediatrics • Non-fasting	• Pulmonary disease • BMI > 35 kg/m^2 • Airway difficulties • Surgery > 4 hours • GORD • Non-fasting • Trauma	• Airway difficulties • Poor dentition • Serious skeletal disease • GORD • Poor co-operation	• Cervical spondylosis	• Expected airway difficulties
Induction	• Midazolam 2 mg • Propofol 2-3 mg/kg • Fentanyl 1-3 µg/kg	• Propofol 2.5 mg/kg • Fentanyl 1 µg/kg	• Propofol 2-4 mg/kg • Fentanyl 1 µg/kg	• Unknown	• Lignocaine 1.5 mg/kg • Fentanyl 2 µg/kg • Thiopental to titration • Rocuronium 0.6 mg/kg
Maintenance	• Sevoflurane • Desflurane	• Propofol • Remifentanil	• Sevoflurane • N_20	• Unknown	• Isoflurane • N_20
Procedures	• Facet infiltrations • Rhizotomy • Spinal decompression • Spinal fusion	• Pilonidal sinus • Melanoma excision on the back • Bone marrow aspiration • Discectomy	• Minor orthopaedics (Achilles tendon) • Pilonidal sinus • EUA anus	• Liposuction	• Posterior varicose vein avulsion • Pilonidal sinus • Achilles tendon repair • Ankle arthroscopy • Calf surgery
Complications	• Malpositioning • Regurgitation • Laryngospasm	• Malpositioning • Blood staining • A sore throat	• Laryngospasm • Malpositioning • A sore throat	• Malpositioning • A sore throat	• A sore throat • Bloody saliva

ASA: American Society of Anesthesiologists, BMI: body mass index, EUA: examination under anaesthesia, GORD: gastro-oesophageal reflux disease, N_2O: nitrous oxide

Table II: Various patient positioning techniques

References	Sharma, Verghese and McKenna[3]	Lopez, Valero and Brimacombe[4]	Ng, Raitt and Smith[5]	Thomas, Bhorkar, D'Silva and Chilqar[6]	Weksler et al[7]
Patient positioned	Pre-/post-induction	Prior to induction	Prior to induction	Prior to induction	Pre-/post-induction
Positions	Prone	Prone Knee-chest	Prone	Prone	Prone
Arms	Above head	Above head	Above head	Not described	Above head

table. Patients who were positioned prior to induction occasionally complained of significant discomfort, alhough these patients usually had short necks or chronic neck pathology.[5] By contrast, supine positioning allows easier access to the patient's airway. Some patients cannot lie in the prone position without difficulty, and must be induced using the supine technique. Supine induction is not devoid of complications, and care must be taken not to dislodge the LMA or injure the patient during the transfer.

Most of the trials positioned the patient's arms above the head. This facilitates easier venous access, and is generally more comfortable for patients. Head positioning is also of importance. Lopez, Valero and Brimacombe[4] placed the head to the left on a head ring to facilitate easier airway access. Ng, Raitt and Smith[5] placed two cushions under the patient's chest, and one under the feet, to free up the abdomen and aid respiration. Thomas, Bhorkar, D'Silva and Chilqar[6] rested the head on a horseshoe-shaped gel cushion at an angle of rotation of less than 30 degrees. The investigators in the trials kept a trolley nearby, in the event that the patient needed to be placed in the supine position urgently.

Physical trauma is possible in the prone position, and care must be taken.[3] Serious complications have occurred in patients undergoing prolonged surgery with a rotated head, most commonly due to carotid or vertebral artery occlusion.[3] None of the procedures in the relevant trial exceeded five hours in duration, and although the duration of surgery is not a contraindication to the use of an LMA Supreme™ for prone surgery, this is only true if the neck is kept in the neutral position.[3]

The manpower required for positioning of the supine patient is considerably more than that needed for patients who are already prone (3.12 vs. 1.0, p-value < 0.0001).[7] The induction to incision time is also less in prone LMA patients, compared to supine intubated patients (23.6 vs. 7 minutes, p-value < 0.0001).[7]

Induction and airway management

Various anaesthetic agents were used for induction (Table I). Preoxygenation of the patient was a trend in most of the trials, averaging from 3-6 minutes.[4,5]

The correct time to insert the LMA remains an issue of debate, or perhaps a difference in technique. Jaw relaxation is frequently used as a marker of adequate anaesthetic depth,[3,5] although a bispectral index (BIS) can also be used. (BIS < 50 is considered to be adequate).[4] To achieve these end-points, most investigators have used supplementary boluses of propofol with manual bag ventilation until LMA insertion. Weksler et al[7] administered a neuromuscular blocker to their patients to facilitate jaw relaxation, although unlike other trials, sodium thiopental was their induction agent of choice.

Removing the head ring after induction is a useful method for inserting the LMA. The anaesthetic assistant holds open the mouth, while the anaesthetist uses one hand to hold the forehead, and the other to insert the LMA.[5] Once inserted, the deflated LMA must then be inflated. However, in the various trials, this varied from inflating it until the leak was eliminated,[3] or until the cuff pressure was set between 20 and 40 cmH_20,[6] or even up to 60 cmH_20[4] with a manometer. The leak pressure is higher in women than in men (29 cmH_20 vs. 25 cmH_20, p-value 0.01), but it must be considered that a size 4 LMA Supreme™ was used in all the patients in the trial, and that a larger LMA Supreme™ might be more pertinent in male patients.[4]

Patients may be allowed to breathe spontaneously or can be ventilated fully. Sharma, Verghese and McKenna[3] allowed patients to breathe spontaneously if the procedure was shorter than 20 minutes in duration. They provided volume-controlled ventilation with tidal volumes set to 5-8 ml/kg in other cases. A neuromuscular blocking agent was administered to patients who displayed an obstructive pattern on spirometry.[3]

A suggested safety protocol for prone LMA surgery is the following:[4]

- Preoxygenate the patient fully.
- Tilt the head and the table to obtain better airway access.
- Fix the LMA Supreme™ securely using strong tape.
- Make sure that the neck is not compressed in any area.
- Insert a nasogastric tube through the provided port.

Exclusion criteria and obesity

Most of the exclusion criteria are designed to prevent two potentially serious complications, namely airway difficulties after induction, and regurgitation or aspiration (Table I).

Potential exclusion criteria surrounding airway difficulties include:

- A known or suspected difficult airway.[5,7]
- Poor dentition.[5]
- Morbid obesity.[3,4]

Potential exclusion criteria surrounding regurgitation and aspiration include:

- Known or suspected gastro-oesophageal reflux disease.[3-5]
- Morbid obesity.[3,4]
- A patient with a full stomach.[3,4]
- Patients with delayed gastric emptying, e.g. trauma.[4]
- Pregnant patients.[3]

Table III: Body mass index distribution[3]

Body mass index	Patients
< 30 kg/m^2	79
30-35 kg/m^2	53
35-40 kg/m^2	20
> 40 kg/m^2	6

Table IV: Haemodynamic changes for the various induction positions

Blood pressure	Prone LMA	Supine endotracheal intubation
Systolic blood pressure	20.9 ± 7.7 mmHg	33.9 ± 13.2 mmHg
Diastolic blood pressure	12.2 ± 5.2 mmHg	23.1 ± 7 mmHg
Mean blood pressure	14.5 ± 6 mmHg	23.6 ± 11 mmHg

LMA: laryngeal mask airway

Other exclusion criteria include poor cooperation,[5] pulmonary disease, surgery longer than four hours in duration,[4] paediatrics[3] and cervical spondylosis.[6]

Obesity has traditionally been one of the exclusion criteria for supraglottic airway placement in the prone position, mainly because of fears that obese patients have more difficult airways in the event that endotracheal intubation is required, that they are more prone to regurgitation, and that their airway pressure is higher, making supraglottic ventilation less optimal.

Of the trials reviewed, the investigators became more daring as time went on. Initial trials[5] did not specifically exclude obese patients, but limited their patients to American Society of Anesthesiology class I and II. (Some practitioners consider morbid obesity to be a class III condition). The average body mass index (BMI) was 30.6 kg/m^2 for females and 26.8 kg/m^2 for males. The patient profile averaged approximately 27.4 kg/m^2 for the control group, and 28.5 kg/m^2 for the trial group in the Weksler et al[7] study.

Lopez, Valero and Brimacombe[4] limited their patients to a BMI of less than 35 kg/m^2, with the average BMI of 24 kg/m^2 for females and 25 kg/m^2 for males.

Sharma, Verghese and McKenna[3] limited their patients to a BMI of less than 55 kg/m^2. Table III shows the BMI distribution of patients in the trials.

An increase in complications in obese patients was not noted in any trial. One trial[3] made a specific point of stating that obese patients suffered a similar rate of complication to non-obese patients, and were not at higher risk.

Haemodynamic parameters

Weksler et al[7] compared haemodynamic changes in two groups of 25 patients after induction. One group was

Table V: Encountered complications

References	Sharma, Verghese and McKenna[3]	Lopez, Valero and Brimacombe[4]	Ng, Raitt and Smith[5]	Thomas, Bhorkar, D'Silva and Chilqar[6]	Weksler et al[7]
Total cases	205	40	73	74	50
LMA required repositioning	13		4	5	
Regurgitation	4				
Change in the size of the LMA	4			2	
Difficulty with insertion	2				
Laryngospasm	1		1		
Leak or high pressures		5			
Blood staining on the LMA		3	2		15
A mild sore throat postoperatively		3	6	2	5
Hoarseness postoperatively			1		

LMA: laryngeal mask airway

induced and intubated in the supine position, while the second group was induced in the prone position and an LMA inserted. The anaesthetic technique (Table I) was the same for both groups.

Patients induced in the prone position with subsequent LMA insertion experienced more favourable haemodynamic parameters.[7]

Table IV details the haemodynamic changes with respect to the various induction positions.

Table V highlights complications that were encountered in the trials.

A 90% success rate was reported when inserting the LMA Supreme™ with the first attempt, and success was achieved with minimal difficulty in the cases that required repositioning. The return of any patient to the supine position for airway manipulation[3,6] was not required. Although regurgitation occurred in four patients,[3] it was found that in all of the cases, this occurred through the nasogastric port of the LMA Supreme™. There were no cases of clinical aspiration using auscultation and postoperative signs of dyspnoea and hypoxia as markers, or long-term pulmonary complications.[3] Other trials reported no regurgitation.[6]

Laryngospasm was rare, and was treated with supplementary propofol.[5] Even in refractory cases of laryngospasm (none of which occurred), the patient can be provided with a neuromuscular blocker. Cases of malpositioning were mainly limited to edentulous patients. Cases of a postoperative sore throat were successfully treated with oral fluids.[5] The incidence of bloody saliva was similar in intubated patients to that in those given an LMA.[7]

Thomas, Bhorkar, D'Silva and Chilqar[6] paid particular attention to cuff pressure during their trial. Only two patients (2.7%) reported a sore throat of mild intensity that was treated postoperatively with analgesics and warm liquids. A sore throat after endotracheal intubation can be as high as 45.4%, although the trial reported an incidence of sore throats after LMA in the prone position of only 7.5%.[6]

Discussion

Prone surgery has traditionally been undertaken using endotracheal intubation in the supine position, followed by patient positioning in the prone position. Complications of this technique include patient trauma during positioning, and the administration of neuromuscular blockers and their side-effects. The use of the LMA (Classic™ or Supreme™) has been investigated as an alternative, although questions regarding the safety of this technique and the potential for serious airway emergencies have been raised.

Several trials performed in the last decade have investigated the safety of this technique during prone surgery. Patient selection and anaesthetic technique varied between the trials, but the patients underwent various procedures in the prone position.

The most common complications involved malpositioning of the LMA. Other complications included regurgitation, laryngospasm, a sore throat and blood on the LMA. Serious complications did not occur, nor did the need to place the patient in the supine position for endotracheal intubation.

Obesity was not found to be a factor that would increase complications in patients undergoing prone surgery with a supraglottic airway.

Patients appear to be more haemodynamically stable if induced in the prone position and managed with an LMA, as opposed to supine endotracheal intubation and turning.

The safety of this technique has never been compared to that of endotracheal intubation in a randomised controlled trial. Therefore, it cannot be recommended as a substitute. However, it obviates certain complications that are experienced with endotracheal intubation. These trials also demonstrated the relative safety of the technique, and although none of them recommended replacing endotracheal intubation at this stage, the implication is that it is a safe alternative.

Author's opinion

A facet block infiltration is a common procedure often requiring this method of anaesthesia. Some practitioners sedate the patient in the prone position with nasal cannula oxygen supplementation, but patients occasionally move when stimulated and disrupt the procedure. Other practitioners intubate patients in the supine position and roll them into the prone position for the procedure. To achieve this, they use a variety of methods, including the use of high-dose propofol and opiates, succinylcholine or low-dose non-depolarising neuromuscular blockers. All of these methods have advantages and disadvantages.

When performing a facet block infiltration, I insert an intravenous cannula, and then ask the patient to position him- or herself comfortably in the prone position, with arms up alongside the head on the arm boards. I then preoxygenate the patient for several minutes before inducing him or her with alfentanil 10 µg/kg and propofol 3 mg/kg. I have also used remifentanil and sufentanil with similar results. The patient's trolley remains in theatre until an airway is established. The patient normally obtains jaw opening shortly after induction, or after further propofol supplementation. Unlike reports from the abovementioned literature, I find it difficult to manually mask ventilate the patient in the prone position, and insert the supraglottic device as soon as possible. I then lift the patient's forehead with one hand and insert an I-gel™ (size 5 for men, 4 for

women and 3 for small women) with the other hand, while the assistant holds the mouth open. I have also used an LMA Supreme™ with equal effect. I then commence positive pressure ventilation, and maintain anaesthesia with sevoflurane and oxygen. The procedure takes approximately 10 minutes, after which the patient is rolled onto his or her bed, and emergence takes place in the recovery room.

I have experienced a situation where I could not ventilate a patient in this position, despite the use of a number of different-sized devices and attempts. The patient was elderly and edentulous, and was placed back on her bed in the supine position and intubated. I have also experienced a situation whereby a patient experiencing laryngospasm responded to a propofol bolus. My approach remains more cautious than those in several of the abovementioned trials. I intubate morbidly obese patients in the supine position, and roll them into the prone position, and I only sedate patients who are significantly ill or elderly with midazolam, sufentanil and propofol.

I prepare for the eventuality of an emergency intubation in all cases, and select patients without airway risk for prone LMA insertion. The technique seems to have a low complication rate, but the potential for catastrophe needs to be respected if approached poorly and with bad planning.

Conflict of interest

I declare that I have no financial or personal relationships that may have inappropriately influenced me in writing this paper.

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