Obstetric GA’s. Am I doing it right?

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INTRODUCTION

Obstetric anaesthesia, specifically for caesarean sections, forms a major proportion of the anaesthetic workload in the public sector in South Africa. The pending triennial ‘Saving Mothers’ report for 2014-2016 indicates that the caesarean section delivery rate for South Africa is 25.7% and for KZN it is 30.5% (The highest in SA). The institutional maternal mortality rate (iMMR) for caesarean deliveries is 165/100000 vs 53/100000 for vaginal deliveries. The iMMR for caesarean deliveries is thus 3 times higher than for vaginal deliveries and implies that anaesthesia has a role to play in either worsening or improving outcomes. The report further examines the primary cause of death, including anesthetic related deaths, and the following is a direct quote from the executive summary of the Saving Mothers 2014-2016 report; “Fifty-six percent of anaesthetic related deaths occurred at DHs and the final cause of death in over half these cases was due to failure to protect the airway during the anaesthesia. It appears clinicians are giving spinal anaesthesia without the ability to give a general anaesthesia and protect the airway.” [2]

Clearly the ability to administer a safe general anaesthetic for caesarean section and manage the associated complications is under scrutiny. The report goes on to discuss that outcomes are worse at district hospitals and indicates the cause is likely due to inexperienced anaesthetic providers [2]. However, this should generate discussion around our current practice and how we are training junior doctors to conduct obstetric general anaesthesia.

This review aims to outline issues specific to caesarean section under general anaesthesia, review our current practice and suggest possible modifications to improve our anaesthetic delivery.

A BRIEF HISTORY OF GENERAL ANAESTHESIA FOR CAESAREAN SECTION

Hamer Hodges first described the use of thiopentone in obstetric anaesthesia in 1959. His anaesthetic involved the use of thiopentone, suxamethonium, oxygen and nitrous oxide [3]. In 1969 a paper by Wilson and Turner titled ‘Awareness during caesarean section under general anaesthesia’ indicated ‘unpleasant recall’ occurred in 17% of patients using this technique. In 1970 Moir modified the technique to include the use of halothane and this reduced the rates of awareness to <1% [3]. In the meantime, cricoid pressure was first described in 1961 and in 1970 the traditional rapid sequence induction was described by Stept and Safar [3,4].

So, in 1970 the recommended general anaesthetic for caesarean section involved a rapid sequence induction with thiopentone and suxamethonium followed by maintenance with 50% nitrous oxide and oxygen and halothane. Almost 50 years later an almost identical technique is taught except substituting isoflurane for halothane. Recently, due to lack of stock, propofol has become the standard induction agent in South Africa. The incidence of failed tracheal intubation is 2.3 per 1000 general anaesthetics for caesarean section and has remained unchanged over the past 45 years [9].
GENERAL ANAESTHESIA FOR OPERATIVE OBSTETRICS
With Special Reference to the use of Thiopentone and Suxamethonium

BY
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Figure 1 – The original paper by Hamer Hodges describing general anaesthesia for obstetrics

Figure 2 – An interesting South African response to Hamer Hodges paper

THE CURRENT SOUTH AFRICAN GUIDELINE (ESMOE)

Having reviewed the history and evolution of general anaesthesia for obstetrics it is important to outline the practice guidelines for South Africa. Figure 3 is the current Essential Steps in the Management of Obstetric Emergencies (ESMOE) protocol for caesarean sections under general anaesthesia while figure 4 is the current ESMOE drugs requirements for casesarean section [5,6,7]. The ESMOE vision is ‘to improve the emergency management of pregnant woman and their infants’. It aims to achieve this by means of a training package aimed at healthcare workers, both nursing and medical, during their student and junior years. From an anaesthetic perspective this entails ESMOE training to medical students, interns and new medical officers entering the field [5]. It is obvious then that the training is basic in nature with a focus on safety. It does however form the backbone of practice that one might adopt as one progresses in an anaesthetic career.
This makes it worthwhile to examine the current ESMOE protocols and compare them with historical guidelines, described above, as well as examine new literature and international best practice. While each point of the guideline could be debated, this review will focus on those aspects that have been questioned in recent literature.

The aspects for discussion include; patient positioning with the suggested technique being the sniffing position. Pre-oxygenation on 100% FiO₂ for 3 minutes. The true rapid sequence induction with cricoid pressure and no mention of mask ventilation. Maintenance with at least 40% oxygen and not more than 1 MAC. Use of short acting muscle relaxant. Failed intubation guidelines. Analgesic strategy with opioids suggested only post delivery. The suggested drugs in the ESMOE guideline will also be discussed including induction agents, muscle relaxants and analgesia.

ISSUES SPECIFIC TO OBSTETRIC GENERAL ANAESTHESIS

It is widely accepted that the anatomical and physiological changes of pregnancy present certain challenges to the anaesthetist. Similarly, the presence of two patients, the mother and the fetus, complicate the anaesthetic as interventions helpful to one may be harmful to the other. This has been termed the “dilemma of obstetric anaesthesia” [10]. Textbooks are written on this extensive subject and this review will focus on two issues that are currently topical in the literature - accidental awareness during general anaesthesia (AAGA) and the difficult airway and failed intubation. These areas will be explored in detail and then various aspects of the anaesthetic technique, mentioned above, will be discussed with a view to lower the risk of these issues occuring. [3,4]

Accidental awareness under general anaesthesia

The 5th National Audit Project (UK) (NAP5) was released in 2014 and it investigated accidental awareness under general anaesthesia including a chapter specifically on AAGA in obstetric anaesthesia. Key findings of NAP5 were that although obstetric GA’s were only 0.8% of cases audited, they contributed 10% of the AAGA cases. This implies that AAGA is more than ten times as common in the obstetric population compared with the general population. The study does question the validity of the numerator and denominator in calculating the incidence, regardless, it is clear that AAGA is far more common in obstetric patients. The actual incidence of AAGA from NAP5 is 1:1200 for obstetrics vs 1:19 000 overall incidence. When looking at caesarean sections specifically, the incidence increased to 1:670. [4,8]

There is limited South African data on the topic and this likely reflects our focus on more basic aspects of obstetric anaesthesia and reducing mortality. However, the risk of AAGA during obstetric anaesthesia is critical to be aware of and one needs to consider the risk factors and strategies to minimise occurrence.

NAP5 identified multiple risk factors for AAGA in obstetrics including the following: The use of rigid drug-dosing protocols leading to underdosing of thioentone and suxamethonium. Limited experience with thioentone by younger anaesthetists. Limited obstetric GA experience due to increasing use of spinals. The lack of sedatives or analgesia prior to induction. Anxiety. The high cardiac output in pregnancy leading to shortened duration of action of intravenous induction agents via rapid redistribution coupled with the prolonged time to adequate partial pressures of the volatile agents. Obesity. RSI coupled with difficult airway. Rapid surgery following induction in certain emergency situations. Low MAC of halogenated volatile with high FiO₂ leading to lower nitrous oxide concentrations. Trainee anaesthetists. [8]
National ESMOE guidelines
for district and regional hospitals

PROTOCOL FOR CAESAREAN SECTION
UNDER GENERAL ANAESTHESIA

PREPARATION

Full history and examination
- NB airway and assess difficulty of intubation
- NB signs of hypovolaemia - decide whether the patient requires resuscitation first

Prepare the patient
- Premedication – sodium citrate 30ml orally, 0 - 30 minutes pre-operatively
- Good IV access, with 500ml clear fluid given as preload
- Urinary catheter

Prepare the theatre
- Full machine check, check ventilator settings
- Check essential equipment and monitoring (ECG, NIBP, SpO2, capnograph)
- Draw up essential drugs

TECHNIQUE

Position the patient
- Wedge under right hip
- Head and shoulders on a pillow, sniffling

Administration of general anaesthesia
- Measure NIBP now, and every 3 minutes
- Establish ECG and pulse oximetry
- Pre-oxygenate 100% FIO2 for 3 minutes
- Start the suction, place Yankauer nearby
- Perform rapid-sequence induction with cricoid pressure, then perform laryngoscopy and intubation
- Confirm correct placement of ETT by capnography, auscultation and clinical impression of chest moving equally
- Ventilate, using at least 40% oxygen and not more than 1 MAC volatile
- Use small doses of short-acting muscle relaxant if necessary

Failed intubation
- Call for help, and try to wake patient up
- Institute mask ventilation while maintaining cricoid pressure

If successful mask ventilation:
(i) Check head position, change to a different laryngoscope blade, assistant to externally manipulate the cricoid, and re-attempt intubation.
(ii) If still unsuccessful, decide whether to continue with mask ventilation OR with spontaneous ventilation OR attempt insertion of LMA OR awaken the patient

If unsuccessful mask ventilation:
(i) One further intubation attempt OR attempted insertion of LMA
(ii) If still unsuccessful and unable to ventilate, and spontaneous ventilation has not resumed, perform an emergency cricothyroidotomy (or tracheostomy), and ventilate the patient.
(iii) Decide whether to continue with the procedure or wake the patient up

After delivery
- Ask obstetrician if they are certain there is no second baby
- Give 2.5 IU oxytocin IVI slowly, over 1 minute
- Can increase volatile, and give multimodal analgesia – morphine 10mg, consider fentanyl 100ug, non-steroidal anti-inflammatory, paracetamol, and infiltrating the wound with local anaesthetic.

Once the surgery is completed
- Switch off the volatile, and give reversal if a non-depolarising muscle relaxant was given use nerve stimulator or see signs of spontaneous recovery first.
- Extubate in theatre, awake and reversed

RECOVERY

Monitoring
- Administer oxygen via 40% venturi mask
- Monitor NIBP and SpO2
- Make sure that the patient is not bleeding
- Make sure that the patient is well analgesed
- Infuse 20 IU oxytocin in one litre of clear fluid over 8 hours (125mls/hr)

Discharge to the ward

Compiled by the ESMOE Anaesthesia Working Group
July 2009 Updated March 2011

Figure 3 – ESMOE protocol for C/S under GA
# National ESMOE guidelines for district and regional hospitals

## Drugs required for anaesthesia for Caesarean Section

<table>
<thead>
<tr>
<th>Drug</th>
<th>How to dilute</th>
<th>Concentration</th>
<th>Dose</th>
<th>Dose for 70kg pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephedrine or</td>
<td>50mg diluted to 10ml</td>
<td>5mg/ml</td>
<td>5mg (1ml) bolus every 2-3 minutes</td>
<td></td>
</tr>
<tr>
<td>Effortil or</td>
<td>10mg diluted to 10ml</td>
<td>1mg/ml</td>
<td>1mg (1ml) bolus every 2-3 minutes</td>
<td></td>
</tr>
<tr>
<td>Phenylephrine</td>
<td>10mg added to 200ml bag of Normal Saline (Mix thoroughly)</td>
<td>50µg/ml</td>
<td>100µg (2ml) bolus every 1 minute</td>
<td></td>
</tr>
<tr>
<td>Sodium-thiopentone or</td>
<td>500mg diluted to 20ml</td>
<td>25mg/ml</td>
<td>4mg/kg</td>
<td>280mg (11ml)</td>
</tr>
<tr>
<td>Propofol</td>
<td>200mg undiluted</td>
<td>10mg/ml</td>
<td>1-2mg/kg</td>
<td>140mg (14mls)</td>
</tr>
<tr>
<td>Succinylcholine / Succinylcholine</td>
<td>100mg undiluted</td>
<td>50µg/ml</td>
<td>1.5µg/kg</td>
<td>100mg</td>
</tr>
<tr>
<td>Oxytocin (only draw up just before foetus is delivered)</td>
<td>5 IU diluted to 5mls</td>
<td>5 IU/ml</td>
<td>2.5 IU given slowly over 1 minute (Later: 20 IU in 1000ml Crystalloid over 6hrs in recovery)</td>
<td></td>
</tr>
<tr>
<td>Atropine</td>
<td>1mg diluted to 10 ml</td>
<td>0.1mg/ml</td>
<td>10-20µg/kg bolus</td>
<td>0.6 - 1.2mg</td>
</tr>
<tr>
<td><strong>Phenytoin (if not drawn as primary agent)</strong></td>
<td>10mg added to 200ml bag of Normal Saline (Mix thoroughly)</td>
<td>50µg/ml</td>
<td>100µg (2ml) bolus every 1 minute</td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>10mg undiluted</td>
<td>5mg/ml</td>
<td>0.1mg/kg (5-10mg)</td>
<td>5-10mg</td>
</tr>
<tr>
<td>Adrenaline</td>
<td>1mg added to 200ml bag of Normal Saline (Mix thoroughly)</td>
<td>5µg/ml</td>
<td>Start with 10µg (2ml) bolus, double the dose every minute until response obtained</td>
<td></td>
</tr>
<tr>
<td>Vecuronium or</td>
<td>4mg mixed with 2ml water</td>
<td>2mg/ml</td>
<td>½ of intubation dose = 0.04 mg/kg</td>
<td>2-4mg</td>
</tr>
<tr>
<td>Atracurium</td>
<td>undiluted</td>
<td>10mg/ml</td>
<td>½ of intubation dose = 0.25mg/kg</td>
<td>20mg</td>
</tr>
<tr>
<td>Glycopyrrrolate</td>
<td>0.4mg undiluted</td>
<td>0.2mg/ml</td>
<td>5-10µg/kg</td>
<td>0.4mg</td>
</tr>
<tr>
<td>Neostigmine</td>
<td>2.5mg undiluted</td>
<td>2.5mg/ml</td>
<td>50µg/kg</td>
<td>2.5mg</td>
</tr>
<tr>
<td>Bupivacaine 0.5% + Dextrose 8%</td>
<td>undiluted</td>
<td>5mg/ml</td>
<td>1.8ml (very short or obese patient: 1.6ml)</td>
<td></td>
</tr>
<tr>
<td>Fentanyl</td>
<td>undiluted</td>
<td>50µg/ml</td>
<td>add 0.2ml (10µg)</td>
<td></td>
</tr>
</tbody>
</table>

Compiled by the ESMOE Anaesthesia Working Group  
July 2009 revised Mar 2011
Interestingly, most of the cases of AAGA in NAP5 occurred at or shortly after induction of anaesthesia and it is thought that this coincides with the period of time when the induction agent is wearing off but the partial pressure of volatile is still increasing. This is referred to as the iv-inhalational interval and is graphically represented below in figure 5. [4,8]

![Figure 5 – The iv-inhalational interval. Image from Chaggar RS, Campbell JP. The future of general anaesthesia in obstetrics. BJA Education. 2017](image)

It is clear then that AAGA is a common and serious complication of obstetric general anaesthesia. It is also clear that both drug choice and anaesthetic technique may contribute to its occurrence. Possible amendments, in view of this, will be described later in this review.

**Difficult airway and failed intubation**

The second common, and more serious, complication of obstetric general anaesthesia is the difficult airway and failed intubation. As mentioned above, the most recent Saving Mothers report found that more than 50% of obstetric deaths due to anaesthetic complications involved failure to manage the airway adequately. This highlights the need to target this area to improve maternal outcomes from the anaesthetic perspective in the South African context. [2]

Management of the obstetric airway is well known to have specific risks associated with it [11]. These risks include aspiration, rapid desaturation, and failed intubation [12]. The incidence of failed tracheal intubation is 2.3 per 1000 general anaesthetics for caesarean section and has remained unchanged over the past 45 years [9]. Difficulty with intubation is unanticipated in two-thirds of cases. There is a preponderance of non-consultant anaesthetists involved in the initial event when failed intubation is encountered [9]. The most important life-threatening risk during management of failed intubation is hypoxaemia [9]. The UK Obstetric Surveillance System (UKOSS) found the incidence of hypoxaemia, defined as SpO₂ < 90%, following failed intubation to be 71%, with an incidence of only 2% in uneventful GA’s. It also found that the lowest maternal SpO₂ was an independent predictor for neonatal ICU admission [9].

Dr Kiwalabye presented an ‘Obstetric Anasethesia Update’ in July 2016 at this forum [13]. This included a thorough review of issues relating to the obstetric airway as well as the latest Difficult Airway Society (DAS) guidelines for obstetrics. Key points raised in this review were the high incidence of difficult and failed intubations in the obstetric population (8 times the general population), predisposing anatomical and physiological factors (increased Mallampati class, reduced FRC and increase oxygen consumption), anaesthetic provider factors (reduced obstetric GA experience due to increasing use of neuroaxial techniques) and system factors.
(unsupervised junior doctors working outside normal working hours) [13]. Many of these same factors were raised in NAP5 as risks for AAGA [8].

For the purposes of this review, algorithm 1 of the DAS guideline for obstetric general anaesthesia is the most relevant but for completeness sake and ease of reference the complete latest DAS guidelines for obstetrics are included below, figures 5 -10 [14].

![Master algorithm – obstetric general anaesthesia and failed tracheal intubation](image)

*See Table 1, †See Table 2

Figure 5 – Master algorithm – obstetric general anaesthesia and failed tracheal intubation [14].
Figure 6 – Algorithm 1 – safe obstetric general anaesthesia [14].

Algorithm 1 – safe obstetric general anaesthesia

Pre-theatre preparation
- Airway assessment
- Fasting status
- Antacid prophylaxis
- Intrauterine fetal resuscitation if appropriate

Plan with team
- WHO safety checklist / general anaesthetic checklist
- Identify senior help, alert if appropriate
- Plan equipment for difficult / failed intubation
- Plan for / discuss: wake up or proceed with surgery (Table 1)

Rapid sequence induction
- Check airway equipment, suction, intravenous access
- Optimise position – head up / ramped + left uterine displacement
- Pre-oxygenate to $F_{1O_2} \geq 0.9$ / consider nasal oxygenation
- Cricoid pressure (10 N increasing to 30 N maximum)
- Deliver appropriate induction / neuromuscular blocker doses
- Consider facemask ventilation ($F_{1O_2} = 20$ cm H₂O)

1st intubation attempt
- If poor view of larynx optimise attempt by:
  - reducing / removing cricoid pressure
  - external laryngeal manipulation
  - repositioning head / neck
  - using bougie / stylet
- Ventilate with facemask
- Communicate with assistant
- Follow Algorithm 2 – obstetric failed tracheal intubation

Success
- Verify successful tracheal intubation
- Proceed with anaesthesia and surgery
- Plan extubation

Fail
- Communicate with senior colleagues

2nd intubation attempt
- Consider:
  - alternative laryngoscope
  - removing cricoid pressure
- 3rd intubation attempt only by experienced colleague

Fail
- Follow Algorithm 2 – obstetric failed tracheal intubation

Algorithm 2 – obstetric failed tracheal intubation

Declare failed intubation
- Theatre team to call for help
- Priority is to maintain oxygenation

Supraglottic airway device
- (2nd generation preferable)
- Remove cricoid pressure during insertion
  (maximum 2 attempts)

Facemask +/- oropharyngeal airway
- Consider:
  - 2-person facemask technique
  - Reducing / removing cricoid pressure

Is adequate oxygenation possible?
- No
- Yes

Follow Algorithm 3
- Can’t intubate, can’t oxygenate

Is it essential / safe to proceed with surgery immediately?
- No
- Yes

Proceed with surgery

*See Table 1, †See Table 2

Figure 7 – Algorithm 2 – obstetric failed tracheal intubation [14].
Algorithm 3 – can’t intubate, can’t oxygenate

Declare emergency to theatre team
Call additional specialist help (ENT surgeon, intensivist)
Give 100% oxygen
Exclude laryngospasm – ensure neuromuscular blockade

Perform front-of-neck procedure

Is oxygenation restored?

Maternal advanced life support
Perimortem caesarean section

Is it essential / safe to proceed with surgery immediately?

No

Yes

Wake

Proceed with surgery?

Figure 8 – Algorithm 3 – can’t intubate, can’t oxygenate [14].

Table 1 – proceed with surgery?

<table>
<thead>
<tr>
<th>Factors to consider</th>
<th>WAKE</th>
<th></th>
<th>PROCEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal condition</td>
<td></td>
<td>No compromise</td>
<td>Haemorrhage responsive to resuscitation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mild acute compromise</td>
<td>Hypovolaemia requiring corrective surgery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compromise corrected with intrauterine resuscitation, pH &lt; 7.2 but &gt; 7.15</td>
<td>Critical cardiac or respiratory compromise, cardiac arrest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compromise corrected with intrauterine resuscitation, pH &lt; 7.15</td>
<td>Sustained bradycardia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fetal haemorrhage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suspected uterine rupture</td>
</tr>
<tr>
<td>Fetal condition</td>
<td></td>
<td>No compromise</td>
<td>Continuing fetal heart rate abnormality despite intrauterine resuscitation, pH &lt; 7.15</td>
</tr>
<tr>
<td>Anaesthetist</td>
<td></td>
<td>Novice</td>
<td>Consultant / specialist</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
<td>Superobstetric</td>
<td>Morbid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Morbid</td>
<td>Obese</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obese</td>
<td>Normal</td>
</tr>
<tr>
<td>Surgical factors</td>
<td></td>
<td>Complex surgery or major haemorrhage anticipated</td>
<td>Single uterine scar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple uterine scars</td>
<td>No risk factors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some surgical difficulties expected</td>
<td></td>
</tr>
<tr>
<td>Aspiration risk</td>
<td></td>
<td>Recent food</td>
<td>No recent food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In labour</td>
<td>In labour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opioids given</td>
<td>Opioids not given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antacids given</td>
<td>Antacids given</td>
</tr>
<tr>
<td>Alternative anaesthesia</td>
<td></td>
<td>No anticipated difficulty</td>
<td>Predicted difficulty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Regional</td>
<td>Relatively contraindicated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Airway awake</td>
<td>Absolutely contraindicated or has failed</td>
</tr>
<tr>
<td>Airway device / ventilation</td>
<td></td>
<td>Difficult facemask ventilation</td>
<td>First generation supraglottic airway device</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adequate facemask ventilation</td>
<td>Second generation supraglottic airway device</td>
</tr>
<tr>
<td>Airway hazards</td>
<td></td>
<td>Laryngeal oedema</td>
<td>Bleeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stridor</td>
<td>Trauma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bleeding</td>
<td>Secretions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None evident</td>
<td></td>
</tr>
</tbody>
</table>

*See Table 1. †See Table 2

Figure 9 – Table 1 – proceed with surgery? [14].
To conclude, both AAGA and failed intubations are common in the obstetric population. It is critical to be aware of the high risk of these negative events and conduct an anaesthetic which aims to minimise their occurrence. It must also be mentioned that there is a link between difficulty in managing the airway and AAGA. This happens because the extra time taken to manage a difficult airway, for example more than one intubation attempt, means the clinical effect of the induction agent may reverse prior to the introduction of the volatile agent. This prolongs the iv-inhalational interval and increases the risk of awareness. It has been suggested in NAP5 that a second syringe of induction agent should be drawn up for use in such situations [8].

**ANAESTHETIC TECHNIQUE**

Keeping in mind the issues discussed above it seems logical to examine our technique for administering general anaesthesia to the obstetric patient with a view to amend any aspects that may improve delivery.

**Patient positioning and preparation**

The use of a wedge to laterally displace the uterus and avoid aortocaval compression is still widely accepted. The wedge should be placed pre-induction and remain in place until after delivery. In addition to wedge placement, there are strong suggestions in current literature that a 20-30 degree head up or ‘ramped’ postion is of benefit [4,14,19]. The benefits include increased FRC (with increased apnoea time to desaturation), reduced breast interference with laryngoscopy, improved view at laryngoscopy and reduced gastro-oesophageal reflux [4,14]. A suggested position is aligning the external auditory meatus with the suprasternal notch [14].
A further consideration is the need to have the patient ‘cleaned and draped’ with the surgeon scrubbed prior to induction. The benefit of this being a more rapid delivery of the neonate but at the expense of increased risk of failed intubation, due to difficult laryngoscopy as a result of patient position and the presence of a screen, and awareness, due to inadequate depth of anaesthesia during intubation and skin incision [10,16]. While general anaesthesia results in lower 1-minute Apgar scores when compared with neuroaxial techniques, by 5 minutes this deficit has largely resolved [10]. The low 1-minute Apgar is the result of transplacental transfer of both intavenous and inhalation agents. The uterine incision to delivery time is more important than induction to delivery time measured by neonatal outcome [10]. For these reasons it could be suggested that a hybrid method be adopted where the surgical team is scrubbed prior to induction but that cleaning and draping of the patient only proceeds after successful endotracheal intubation is confirmed.

Pre-oxygenation

Numerous techniques for pre-oxygenation are described in the literature but the need to pre-oxygenate with 100% FiO₂ is consistent [4,14,15,16,19]. This is logical given the 40% reduction in FRC in pregnancy coupled with the 20% increase in oxygen consumption [15]. Historically, 3 minutes of of tidal volume breathing with 100% FiO₂ was suggested but recent evidence shows that 2 minutes is adequate [14]. Another method is vital capacity breaths of 100% FiO₂ for 4-8 breaths [15,16]. More relevantly, the best marker for adequate pre-oxygenation, whichever method is chosen, is the end-tidal oxygen fraction with the DAS guidelines suggesting a target of 90% [14].

Newer adjuncts have been suggested to increase the time to hypoxaemia. These generally revolve around the principle of bulk flow to achieve oxygen delivery to the alveoli during apnoea. They include maintaining a tight seal with the facemask and high flow oxygen (>10L/min), high flow nasal cannulae oxygen (>5L/min) and nasal-pharyngeal catheters delivering oxygen [4,14].

The importance of adequate pre-oxygenation cannot be stressed enough given the combination of rapid desaturation and high risk of difficult airway management.

Induction agent and muscle relaxant

Thiopentone has long been the induction agent of choice for obstetric general anaesthesia. In the UK it is still the most commonly used induction agent [4] but elsewhere in the world, including our setting in KZN, propofol has become the more common drug used. The debate for which agent is best is strongly contested with different authors arguing the risks and benefits of each. In view of this, the best approach might be to review the characteristics of each agent in the obstetric setting and keep this in mind when using either.

Thiopentone is well known in obstetrics, particularly in older anaesthetists but younger anaesthetists may not be familiar with it. It is relatively cardiostable. It is better studied in terms of neonatal effects than other agents. It has a rapid onset and longer duration than propofol. However, NAP5 reported high incidence of AAGA due to underdosing of thiopentone. It requires pre-mixing and may be confused with antibiotics. There is also recent evidence of overdosing in haemodynamically compromised patients, possibly as a result of unfamiliarity with it. Thiopentone is in short supply. [3,4,8,14]

Propofol is far more familiar to the newer generation of anaesthetists due to common use in non-obstetrics. There is no evidence of more adverse events on the neonate when compared
with thiopentone [4]. There is no pre-mixing needed. Propofol is cheaper than thiopentone. Propofol blunts airway reflexes more than thiopentone. [3,4,8,14]

A 2018 meta-analysis in the *Journal of Clinical Anesthesia* compared thiopentone with other induction agents and included studies where the primary outcome variables were arterial or venous umbilical blood gas analysis or Apgar score. It also used AAGA and maternal systolic blood pressure as additional outcomes. Broadly this study found no significant difference between thiopentone and propofol in terms of primary outcome variables except for a lower umbilical arterial pO$_2$ with propofol. It is unclear what implication this has on neonatal outcome. The study also found that ketamine use resulted in more neonates with Apgars <7 at 1 and 5 minutes when compared with thiopentone. It is unclear if ketamine was chosen in these studies due to maternal compromise. [18]

Ketamine use is limited by emergence phenomena but is an acceptable choice in haemodynamic compromise, as is etomidate [16,17].

Perhaps the key point is to be familiar with the agent being used and to use appropriate doses. The recommended thiopentone dose is 5mg/kg. [8,14]

Muscle relaxant is less controversial and the in the South African public sector context, without access to sugammadex, the choice is even simpler. Suxamethonium remains the agent of choice for rapid sequence induction, again with emphasis on correct dosing to achieve optimal conditions for intubation. The recommended dose for suxamethonium is 1.5mg/kg. High dose rocuronium (1.2mg/kg) provides similar onset time and intubating conditions to suxamethonium and in centres with access to sugammadex it has been used in obstetrics. The non-depolarising muscle relaxants do not cross the placenta in significant amounts under normal circumstances. The long duration of action of high dose rocuronium precludes its’ use in the absence of sugammadex. [4,14,15,17]

**Cricoid pressure and face-mask ventilation**

The use of cricoid pressure has been a standard feature of the RSI for decades but recently its requirement has been strongly debated. However, it is still widely advocated in obstetric general anaesthesia for the purposes of reducing regurgitation risk [4,14,16]. Problems with cricoid pressure include difficulty with mask ventilation, poor laryngoscopy view, difficulty with endotracheal intubation and difficulty with insertion of supraglottic airway devices [4,14]. There should be a low threshold to reduce or release cricoid pressure if any of the above difficulties are encountered [4,14].

The DAS suggestion for cricoid pressure is 10N of force prior to induction, increased to 30N of force after loss of consciousness [14]. One should counsel the patient prior to initiation of cricoid pressure. Devices have been invented to measure cricoid pressure but these are not in common use.

Perhaps more contentious than the use of cricoid pressure is the recent introduction of facemask ventilation which was not traditionally used in RSI’s. The reason for the omission of facemask ventilation is the possibility of insufflating the stomach and increasing the risk of regurgitation. However the latest DAS guidelines in obstetrics suggest using low pressure (<20cmH$_2$O) mask ventilation with cricoid pressure [14]. The benefits of this addition is the reduced likelihood of hypoxaemia and an early indicator of whether bag-mask ventilation is possible [14]. A further benefit, in view of the discussion of AAGA above, is the potential early introduction of halogenated volatile and thus a reduction in the iv-inhalational interval.
Maintenance

The main issues to consider for maintenance of anaesthesia are the use of nitrous oxide, the oxygen fraction and the Minimum Alveolar Concentration (MAC) target. Nitrous oxide is still commonly used in obstetrics with benefits being rapid uptake, analgesia and less tocolytic effect on uterus. Historically oxygen concentration of 50% has been used but multiple studies have shown no change in fetal outcome with concentrations of 33% (in the absence of fetal compromise) [8,19]. This allows for higher nitrous oxide concentration and lower halogenated volatile without increasing the risk of AAGA. As mentioned earlier, prolonged iv-inhalational interval is a risk for AAGA, which most commonly occurs just after induction. For this reason it is now being advocated to use an ‘overpressure’ technique to rapidly achieve adequate end-tidal concentrations of volatile agents [4,17]. This involves initial high volatile concentrations with high fresh gas flows. It is implied that vigilence is required to adjust these settings when target MAC is achieved.

Target MAC is still debated as it is thought that MAC requirements in pregnancy may be reduced by up to 40% [17,19]. Risks of increasing the target MAC are thought to be increased neonatal sedation and increased blood loss due to uterine atony but both of these have been overstated [4,8]. An end-tidal MAC of 0.5 for the halogenated volatile combined with nitrous oxide, as above, has been suggested [8]. Prolonged exposure of the neonate to volatile anaesthetic agents may result in sedation and low 1-minute Apgars but this is easily managed with assisted ventilation to expel the volatile agent via the lungs [15].

Opioids

Opioid timing has long been a highly contentious point in obstetric anaesthesia. Many fear giving opioids pre-delivery due to the respiratory depressant effects on the neonate as opioids cross the placenta [15,19]. Benefits of administering a rapid onset short acting opioid include reduction in the iv-inhalational interval, analgesia for laryngoscopy and intubation, and analgesia for surgical incision [4]. Unfortunately, while most recent literature notes that there is no evidence-base to support harmful effects on the neonate, this is always followed by mentioning that more research is required to determine best drug, dosing and timing of administration [4,8]. Alfentanil is classically described for blunting intubation response [17,19] and more recently remifentanil has been used, although it was associated with increased need for respiratory support [17].

Given the lack of consensus in the literature it is difficult to make a recommendation for opioid practice in the absence of a clinical indication such a pre-eclampsia or cardiac disease. One should consider the level of care available post delivery, and ensure good communication with those responsible for resuscitation and care of the neonate.
THE ‘MODIFIED GUIDELINE’ FOR OBSTETRIC GENERAL ANAESTHESIA?

In the interests of making this review practically applicable this section will summarise the various issues discussed above and present a possible anaesthetic technique based on the evidence presented. While clinical scenarios vary, this summary should serve as a broad guide on the various amendments one can make to their technique when administering an obstetric GA.

Patient position
- Wedge under right hip
- 20-30 degree head up / ‘ramped’
- Unnecessary to ‘clean and drape’ prior to induction (if no indication for emergency delivery)

Pre-oxygenation
- 100% FiO$_2$ for 2 minutes (Aim F$_{ET}$O$_2$>90%)
- High flow (10L/min) with tight fitting mask maintained after induction
- Consider high flow nasal cannula (5L/min)

Cricoid pressure
- 10N pre-induction increased to 30N post-induction
- Maintained until successful endotracheal intubation confirmed

Induction agent and muscle relaxant
- Propofol 2 -2.5mg/kg (Or thiopentone 5mg/kg)
- Suxamethonium 1.5mg/kg

Facemask ventilation
- Gentle bag/mask ventilation (<20cmH$_2$O)
- ‘Overpressure’ with halogenated volatile

Maintenance of anaesthesia
- FiO$_2$ 33% in N$_2$O (if no fetal compromise)
- Halogenated volatile end-tidal MAC 0.5

Analgesia
- Opioids post delivery
CONCLUSION
This review has aimed to describe the history and to outline current practice of obstetric general anaesthesia, to examine issues specific to obstetric general anaesthesia, notably the high incidence of accidental awareness under general anaesthesia and the difficult airway and failed intubation, and then to examine various aspects of the anaesthetic technique that contribute to these issues. Finally, a possible method for the conduct of general anaesthesia for obstetrics has been suggested, based on current literature, to minimise these complications. This is a broad topic with a long history but important changes have been recommended in recent literature and these should be incorporated into one's practice.
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