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General anaesthesia for elective cesarean section in resource-limited settings

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INTRODUCTION

General anaesthesia for caesarean section entails the risk of life-threatening complications such as difficult airway management and aspiration pneumonia, and it is therefore recommended that it be avoided whenever possible in favour of neuraxial anaesthesia.[1] High-income countries (HICs) where this policy is widely followed have seen a rapid decrease in maternal mortality associated with general anaesthesia for caesarean section[2], but in low- and middle-income countries (LMICs), general anaesthesia still remains a risk factor for caesarean-related maternal mortality.[3] In this article, we explain safe methods of general anaesthesia for elective caesarean section for use in LMICs.

Indication of general anaesthesia for elective caesarean

The most common indication for a general anaesthesia for caesarean section in the HICs is for a category 1 section, and it is thought that general anaesthesia is relatively contraindicated for elective caesarean section. In LMICs, however, general anaesthesia may be chosen even for elective caesarean section for the following three reasons.

a) If the anaesthesia provider is technically unable to provide neuraxial anaesthesia: Recently, the World Health Organization (WHO) and World Federation of Societies of Anaesthesiologists (WFSA) have published guidelines stating that a fully trained anaesthetist should be responsible for all anaesthetic procedures[4], but in LMICs the anaesthesia provider may not necessarily be a trained anaesthetist. Furthermore, training in general anaesthesia is prioritized in the training of anaesthesia providers in LMICs.[5] However, the managers of facilities where caesarean sections may be performed should actively train the anaesthesia providers employed in these facilities to enable them to provide neuraxial anaesthesia in addition to general anaesthesia.

b) If the risks of general anaesthesia are not fully understood by anaesthesia providers: Even when an anaesthesia provider is capable of providing both general and neuraxial anaesthesia, if they do not fully understand the risks of general anaesthesia for caesarean section, they may choose general anaesthesia without due consideration, putting the patient at risk as a result. To avoid such situations, the managers of institutions where caesarean sections may be performed should offer anaesthesia providers opportunities for training with a special focus on obstetric anaesthesia. Examples are the Safer Anaesthesia From Education (SAFE) obstetrics project in the UK and the No Pain Labour & Delivery Global Health Initiative in China.[6,7] If the managers of an institution where caesarean sections may be performed are unable to offer such educational opportunities, neuraxial anaesthesia should be specified to be the standard method for caesarean sections in institutional protocols. (This article is mainly written for anaesthetic practitioners. However, it is sometime difficult for them to change their daily practice without supportive understanding of their manager. Hence, it is recommended to persuade the managers using this article.)

c) If neuraxial anaesthesia may be associated with risk: For patients in whom neuraxial anaesthesia may entail a medical risk, general anaesthesia can be considered, but it should be remembered that in most cases general anaesthesia is also highly risky for these patients. For example, in patients with clotting function problems (such as haemolysis, elevated liver enzymes, and low platelets (HELLP) syndrome), neuraxial anaesthesia entails the risk of neuraxial haematoma, but general anaesthesia carries the more serious risk of intracranial haemorrhage. In obese patients, neuraxial anaesthesia entails the risk of puncture difficulty, but general anaesthesia carries the more serious risk of difficult

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airway management. The choice of anaesthesia method in at-risk pregnant women requires a high level of judgment, and managers of institutions dealing with high risk pregnant women should enable those responsible for anaesthesia to undergo further higher level training.

Preparations for general anaesthesia

The WHO and WFSA have listed the facilities and equipment, drugs, and monitors that should be readily available at institutions to provide safe anaesthesia.[4] The items on this list that are particularly vital in general anaesthesia for caesarean section are explained below.

a) Facilities and equipment

- **Oxygen supply:** In general anaesthesia for caesarean section, patients are at high risk of hypoxia, and it is essential that preparations be made to provide a reliable supply of high-concentration oxygen. This oxygen may be supplied via a pipeline, oxygen cylinder, oxygen concentrator, or other means, but if the supply is interrupted the patient's life is put at risk, and a backup supply method should always be secured.
- **Electricity supply:** Caesarean sections under general anaesthesia can be provided even in institutions with no electricity supply. In LMICs the electricity supply is often unstable, and even in institutions with a steady supply of electricity, measures should be taken to ensure that its interruption is not a problem.
- **Suction device:** General anaesthesia for caesarean section entails the risk of vomiting and aspiration, and a suction device to aspirate the mouth and airway is therefore essential. During the induction of anaesthesia, in particular, a foot-pedal-operated suction device should be available for immediate use.
- **Anaesthesia machine:** The roles of anaesthesia machines in general anaesthesia are to regulate the concentrations of oxygen and inhalational anaesthetics and supply them to the inhalation circuit, and to provide positive pressure ventilation via this circuit. Inhalational anaesthetics include nitrous oxide and volatile anaesthetics (such as halothane, enflurane, isoflurane, and sevoflurane). Nitrous oxide is supplied from cylinders or centrally piped. Volatile anaesthetics are supplied via a vaporizer. Electric power or pressurized gas may be used as the power source for positive pressure ventilation, but even if both of these are lacking, positive pressure ventilation may still be performed manually. Anaesthesia machines should be installed and maintained in accordance with the circumstances of the institution concerned.
- **Equipment for airway management:** Airway management in pregnant women is often difficult. Adequate preparations must therefore be made to deal with airway management difficulties.[8] A narrow tracheal tube (internal diameter 6–7 mm) should be used. Because pregnant women's breasts are enlarged, a short-handled laryngoscope is preferable if available. A gum elastic bougie (GEB), supraglottic airway (SGA), or similar device should also be available in preparation for difficult airway management. Although debate continues on whether or not an SGA should be the first choice for use in general anaesthesia for caesarean section, it is undoubtedly useful in emergencies. The widespread use of cheap video laryngoscopes is also desirable.

b) Medications and intravenous fluids

- **Anaesthesia induction agents:** In HICs, the first-choice agent for the induction of general anaesthesia for caesarean section is currently in the process of shifting from thiopental to propofol. However, when they are used for the induction of anaesthesia for caesarean section, both may cause maternal hypotension and respiratory depression. On the other hand, ketamine dose not induce maternal hypotension and respiratory depression. Hence, it is extremely useful in situations when general anaesthesia for caesarean section must be chosen in LMICs. However, in countries where ketamine is the target of measures to prevent drug abuse, its use in medical settings may be restricted, and the WFSA has launched a campaign for the approval of ketamine as a general medication. Managers of institutions where general anaesthesia for caesarean section is required should take measures to ensure that ketamine can be officially used as a drug in their institution.
- **Muscle relaxants:** As airway management may be difficult in general anaesthesia for caesarean section, succinylcholine is the first choice for immediately restarting spontaneous respiration, should intubation fail. However, succinylcholine entails the risk, albeit rare, of fatal complications such as malignant hyperthermia and hyperkalemia, and caution is therefore required. Recently, short-acting non-depolarizing muscle relaxants (such as vecuronium) have been used instead of succinylcholine, but as sensitivity to muscle relaxants changes in pregnant women, the priming principle cannot be used when using non-depolarizing muscle relaxants for induction.
- **Vasopressors:** Pregnant women are liable to develop hypotension in the supine position, and a vasopressor must be available for immediate use. Ephedrine was formerly the first-choice vasopressor for use during caesarean section, but this has recently been replaced by phenylephrine. Even more recently, the value of norepinephrine has been described. The doses used in bolus administration for hypotension are ephedrine 5–10mg, phenylephrine 0.05–0.1mg, and norepinephrine 0.005–0.01mg.

c) Monitoring

- **Trained anaesthesia provider:** Clinical observations of vital signs (including blood pressure, heart rate, oxygenation level, respiration rate and type, and listening to respiratory and heart sounds) by a fully trained anaesthesia provider are the most important form of monitoring, and can replace monitoring by an effective device. In general anaesthesia for caesarean section, continuous observations should be made by a trained anaesthesia provider.
- **Pulse oximetry:** In general anaesthesia for caesarean section, pregnant women are more likely to be at risk of hypoxia, and pulse oximetry is essential. Institutions performing general anaesthesia for caesarean section should make every possible effort to obtain a pulse oximeter. Lifebox, which is s an NGO devoted to safer surgery and anaesthesia in low-resource countries, is continuing activities to provide cheap, reliable, and highly durable pulse oximeters in LMICs.[9]

- **Non-invasive arterial blood pressure (NIBP):** Because maternal hypotension reduces the oxygen supply to the fetus, blood pressure is measured once a minute from the induction of anaesthesia until delivery. As haemorrhage may also cause hypotension after the infant has been delivered, blood pressure is also measured at least once every five minutes after delivery. An automated sphygmomanometer is useful for this purpose.
- **Electrocardiography (ECG):** In HICs, ECG is a standard form of monitoring during anaesthesia, but if the pulse rate can be confirmed by pulse oximetry then an ECG monitor may not be necessarily required. Of course, if an ECG monitor is available it is useful for detecting problems such as arrhythmias and electrolyte disturbances.
- **End-tidal carbon dioxide detector:** As airway management in pregnant women is often difficult, an end-tidal carbon dioxide detector is useful for definite confirmation that tracheal intubation has been successful. Capnography is even more useful.
- **Audible signals and alarms at all times:** Alarms to signal abnormal monitor results should be activated at all times.

Specific methods of general anaesthesia

In HICs, the safety of general anaesthesia for caesarean section has dramatically improved in recent years thanks to advances in monitoring, drugs, and medical devices.[10,11] However, in LMICs where these advances are not so widely available, general anaesthesia for caesarean section still remains a procedure that may place patients' lives at risk. The following points must be followed to provide general anaesthesia for caesarean section safely in LMICs.

a) *Preoperative assessment:* A preoperative assessment is performed based on an understanding of the physiological changes associated with pregnancy, and a careful judgment made on the method of anaesthesia. Airway assessment is particularly important.

b) *Fasting from drink and food:* Because gastric emptying time is prolonged during pregnancy, fasting from food and drink must be strictly imposed before a planned caesarean section, and all patients should be treated as having a full stomach even with a sufficient fasting period.

c) *Premedication:* When general anaesthesia is chosen, an antiemetic and a non-powder antacid are administered.

d) *Sign-in:* Time-outs are implemented following the WHO checklist.

e) *Monitor attachment:* Because pregnancy-associated physiological changes mean pregnant women are liable to develop hypoxia, pulse oximetry is essential. Blood pressure should ideally be measured frequently with an automated sphygmomanometer. Measurements are made once a minute until the infant is delivered, and once every five minutes after delivery.

f) *Preoxygenation:* Pure oxygen is inhaled for five minutes before anaesthesia is induced. For an emergency section, the patient can be asked to take four deep breaths for denitrification.

g) *Induction of anaesthesia:* If thiopental is used, 4mg/kg is administered intravenously, and a muscle relaxant (succinylcholine) is administered immediately after the patient has fallen asleep. After the airway has been secured, the inhalational anaesthetic is started.

h) *Airway management:* After muscle relaxant administration, the lower jaw is raised, and positive pressure ventilation is not performed while spontaneous respiration is present. Even after spontaneous respiration has ceased, the use of positive pressure ventilation is kept to a minimum as long as blood oxygen saturation (SpO_2) is maintained, and intubation is performed as soon as muscle relaxation has been confirmed. Cricoid pressure is recommended to prevent aspiration during tracheal intubation. Cricoid pressure is released if it interferes with tracheal intubation.

i) *Start of surgery:* Surgery is started after confirmation that the airway has been properly secured. The inhalational anaesthetic is administered at 1-1.5 minimum alveolar concentration (MAC) until the infant is delivered. If nitrous oxide can be used, it is administered at a concentration of around 50%.

j) *Post-delivery management:* Because inhalational anaesthetics relax the uterus, after delivery of the infant their concentration should be reduced to around 0.5 MAC. The incidence of awareness is increased among the patients undergoing general anaesthesia for caesarean section, and caution is therefore required. Because pregnant women are more sensitive to muscle relaxants, additional administration is not necessarily required.

k) *Oxytocin administration:* After the delivery of infant, intravenous administration of 5 U of the uterotonic oxytocin has been recommended. It should be noted, however, that excessive oxytocin may cause maternal hypotension.

l) *Waking:* Complications such as aspiration and hypoxia on extubation are greater risks in general anaesthesia for caesarean section, and the same level of caution is required as during induction. If a non-depolarizing muscle relaxant has been used, an antagonist is required. A muscle relaxation monitor should ideally be used if possible. Neostigmine, the non-depolarizing muscle relaxant antagonist, entails the risk of arrhythmia, and atropine is therefore administered prophylactically.

m) *Postoperative analgesia:* Early mobility is recommended to prevent pulmonary thrombosis following caesarean section. Efforts should be made to provide adequate postoperative pain relief with local anaesthetic infiltration, acetaminophen, NSAIDs, and other analgesics to enable early mobility.

CONCLUSIONS

Circumstances under which general anaesthesia must be chosen because neuraxial anaesthesia cannot be provided should be urgently improved. The WHO and WFSA have published statements that anaesthesia is clearly a medical procedure and that it should be provided by a trained anaesthetist to assure its safety.

Whether neuraxial or general anaesthesia is chosen for caesarean section, both entail greater risks than normal anaesthesia. If general anaesthesia must be chosen, efforts should be made to manage the anaesthesia in full consideration of the special nature of pregnant women. Make use of the SAFE-OB educational project and other available information.

In HICs, while every effort is made to avoid general anaesthesia for caesarean section and choose neuraxial anaesthesia whenever possible, efforts to improve the safety of general anaesthesia for caesarean section are also ongoing, and mortality associated with general anaesthesia for caesarean section has dropped dramatically. Safe methods of general anaesthesia for caesarean section that are appropriate to the circumstances of LMICs must be established. The use of ketamine is particularly important.

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