A Comprehensive Guide to Anaesthesiology for Undergraduate Students in Africa

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Edited by

Kingsley Ufuoma Tobi
and Paulin R. Banguti

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She has won several awards in the course of her professional career including the Famewo Memorial Prize and Ffoulkes-Crabbe Prize from the National Postgraduate Medical College of Nigeria (2010), the World Federation of Societies of Anaesthesiologists WFSA-Baxter Award (2016) and the American Society of Anesthesiologists Global Scholar Award (2018), amongst others. Dr Osazuwa is married with children. Her hobbies are reading, music, movies and travelling.

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ABOUT THE BOOK

Undergraduate medical students in most parts of Africa often find it difficult to access a comprehensive textbook on anaesthesia. The available ones are either too cumbersome or contain inadequate information for undergraduate students rotating through anaesthesia.

Furthermore, most medical schools across the continent offer a limited anaesthesia teaching schedule, which ranges from four to six weeks.

This book seeks to solve these problems by making a textbook on anaesthesia which covers a wide range of topics readily available to medical undergraduates on the continent.

This book has been written by specialists across Africa in different fields of anaesthesia, pain medicine and critical care medicine. This makes the book unique as it presents the topics covered with different backgrounds and biases.

The approach of the chapters has undergraduate medical students in mind, making it easily understandable. There are helpful mnemonics throughout the book to aid memory and recollection of facts.

In addition, there are practice examination questions at the end of each chapter which comprise single best answer (SBA) questions and short answer questions (SAQs) with their answers.

There is a chapter providing an introduction to project writing and tips for answering anaesthesia questions.

This book, *A Comprehensive Guide to Anaesthesiology for Undergraduate Students in Africa*, is a complete package of information which is presented in a student-friendly manner.

Of note is that this book is also useful for postgraduate students in anaesthesia, lecturers and anaesthesia practitioners.

FOREWORD

Today I am honoured to write the foreword to Dr Kingsley Tobi's book on anaesthesia. I found the book very comprehensive and a useful guide for medical students and other practitioners of anaesthesia. When the author asked me to write this foreword, my heart became illuminated with hope that the younger ones in the art of anaesthesia can stay determined to keep the flame burning.

The contributors to the various chapters are seasoned anaesthetists from all over the world who have penned down their personal experiences and knowledge of the art. I have studied and taught anaesthesia for well over 30 years and can attest that the chapters gathered here can serve as a shining path for both students in medical schools and resident doctors in their formative years in anaesthesia.

It is my hope and expectation that this book will provide an effective learning experience and reference resource, whether for medical students or anaesthesia practitioners, leading to optimal care and patient safety.

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The Almighty God, the source of all that is good.

My wife, Pastor Oluwafayokemi Tobi, and our children, Joyce, Precious and Jemimah.

Prof. Sotonye Fyneface-Ogan and Dr Sudene van Zyl.

SECTION 1:

GENERAL

CHAPTER 1

INTRODUCTION TO ANAESTHESIA

K U TOBI

The practice of anaesthesia is as old as man. In Genesis 2:21, the Bible reads, “And the Lord God caused a deep sleep to fall on Adam, and he slept, and He took one of his ribs and closed up the flesh in its place.” Since that time, the practice of anaesthesia has significantly evolved into a clinical speciality.

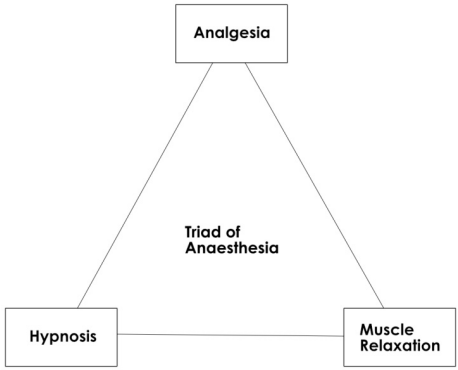
However, the first documented use of general anaesthesia in clinical practice was by William G. Morton, who demonstrated ether anaesthesia in a patient at the Massachusetts General Hospital, Boston, USA, on 16/10/1886.

Definitions

General anaesthesia is a physiologic state characterized by a reversible depression of the central nervous system following the administration of drugs.

Local anaesthesia refers to a reversible blockage of conduction of nerves supplying a circumscribed body area due to the effects of drugs.

Components of anaesthesia: The TRIADS of general anaesthesia are hypnosis, analgesia and muscle relaxation +/- repression of unwanted reflexes.



PICTURE BY THE RESEARCH HUB +264 (0) 81 390 9265

Balanced anaesthesia: This is a concept proposed by John Lundy in 1926, in which a combination of drugs is used to produce a component of the triad of anaesthesia. For example,

- Hyposis: e.g. propofol, midazolam etc.
- Analgesia: opioids, NSAIDs
- Muscle relaxation: neuromuscular blockers (suxamethonium, rocuronium)

The purpose of balanced anaesthesia makes the conduct of anaesthesia less dangerous and also minimises potentially adverse anaesthetic agents.

Stages of Anaesthesia (Consider the mnemonic, "Deep SEA" in reverse order)

Guedel in 1937 gave the classical description of the stages of anaesthesia in patients who were premedicated with morphine and atropine under anaesthesia with ether in air.

- **Stage 1:** (stage of analgesia)

The presence of normal reflexes characterizes stage 1 of anaesthesia, and it ends with the loss of eyelash reflex and unconsciousness. It is attained when using 50% nitrous oxide in oxygen.

- **Stage 2:** (stage of excitement)

Stage 2 is characterized by irregular breathing, struggling and dilated pupils. Laryngeal and pharyngeal reflexes are active, and stimulation at this stage may produce laryngospasm. It ends with the onset of automatic breathing and loss of eyelid reflex. This stage is commonly seen with inhalational induction.

- **Stage 3:** (stage of surgical anaesthesia)

Stage 3 deepens through four planes with an increasing concentration of anaesthetic drugs.

Plane I: eyes are centrally placed with a loss of conjunctiva reflex. Swallowing and vomiting reflexes are depressed, and lacrimation increases. Pupils are normal/small.

Plane II: there is an onset of intercostal muscle paralysis and loss of corneal reflex. There is regular breathing, and pupils become larger. Lacrimation is increased.

Plane III: there is complete intercostal muscle paralysis, and breathing becomes shallow. Light reflex, laryngeal reflexes and lacrimation are all depressed.

Plane IV: there is diaphragmatic paralysis with depressed carina reflexes.

- **Stage 4:** (stage of overdose)

This stage is associated with apnoea and dilated pupils with depressed brainstem reflexes due to the high concentration of anaesthetic.

The process of general anaesthesia is divided into induction, maintenance and emergence.

Induction of anaesthesia refers to the transition from an awake to an anaesthetized state.[1] This can be achieved normally via the intravenous or inhalational administration of anaesthetic induction agents.

Maintenance of anaesthesia refers to keeping a patient anaesthetized and can be achieved using volatile inhalational agents or continuous infusion of intravenous agents.

Emergence is a transition period from an anaesthetized state to an awake state, and it involves switching off maintenance agents and reversing residual muscle paralysis.

Practice Examination Questions

1. Concerning Guedel's stages of anaesthesia: (10 marks)
   a. Briefly describe Guedel's stages of anaestehsia. (8 marks)
   b. At what stage of anaesthesia can surgical incision be made? (2 marks)

2. General anaesthesia is a physiologic state characterized by reversible depression of the central nervous system following administration of drugs. (10 marks)
   a. What are the components of general anaesthesia? (6 marks)
   b. What is balanced anaesthesia? (4 marks)

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CHAPTER 2

PREOPERATIVE ASSESSMENT IN ANAESTHESIA

K U TOBI & L NANYALO-NASHIMA

Introduction

Preoperative assessment of patients scheduled to undergo surgery and anaesthesia is vital. Inadequate preoperative assessment or lack of proper patient preparation is unethical and predisposes to increased incidence of perioperative morbidity and mortality.

Factors that contribute to anaesthesia-related morbidity and mortality include:

- Inadequate preoperative assessment
- Inadequate preparation and resuscitation
- Inappropriate anaesthetic technique
- Inadequate perioperative monitoring
- Lack of supervision
- Poor postoperative care

Purposes of preoperative assessment: ("ABCDEF")

- To allay ANXIETY of the patients before surgery
- To create a BOND with the patient
- To obtain informed CONSENT
- To administer DRUGS preoperatively (premedication)
- To adequately EVALUATE patients' clinical state (investigations)
- To FORMULATE an anaesthetic plan for the patient.
- To observe FASTING guidelines as appropriate.

Components of preoperative assessment:

- History

This includes a history of presenting conditions and comorbidities such as rheumatic heart disease, ischaemic heart disease, hypertension, diabetes,

tuberculosis, asthma, and HIV. Other factors include a history of previous anaesthetic exposure, drug history/history of allergy, and social history such as a history of smoking and alcohol/drug misuse (e.g. acute intoxication, withdrawal, chronic end-organ disease)

- Investigations:

Preoperative assessment involves a request for both routine and specific laboratory investigations. Routine investigations include a full blood count or complete blood count test and urinalysis (searching for glucose, protein, blood and casts in the urine). They also include measuring electrolytes, urea, creatinine, and blood glucose levels, or performing chest X-rays and electrocardiography for patients older than 50.

- Premedication:

This strictly refers to medications administered 1-2 hours before induction of anaesthesia. They include anxiolytics, analgesics, acid prophylaxis, atropine, prokinetics and prophylaxis against nausea and vomiting.
Examples of premedication are:

- Benzodiazepines, e.g. diazepam and midazolam – usually given to reduce anxiety
- Histamine-2-receptor blockers, e.g. cimetidine, ranitidine etc., to reduce gastric acidity
- Prokinetics such as metoclopramide are given to reduce gastric emptying time and protect against nausea and vomiting
- Analgesics such as opioids, e.g. morphine for pre-emptive analgesia

- Fasting guidelines:

Patients scheduled for elective surgical procedures are to observe fasting guidelines. The American Society of Anesthesiologists (ASA) has provided fasting guidelines as no clear fluids for two hours, breast milk for four hours, light meals for six hours and heavy meals for eight hours. See the table below:

Ingested material	Minimum fast (hr)
Clear liquid	2
Breast milk	4
Infant formula milk	4-6
Non-human milk	6
Light meal	6
Heavy meal	8

- Preoperative optimization

The aim is to recognize and correct any reversible problems to improve patient outcomes. In elective surgery, any reversible factor which may

impact anaesthetic risk is optimized prior to anaesthesia and surgery. In emergency surgery however, there should be a balance of risk of the proposed surgery and patient safety.
An optimization is practically orientated and aims to render the patient as fit as possible for anaesthesia and surgery to reduce morbidity and mortality. Smokers should be encouraged to stop smoking eight weeks before elective surgery to reduce postoperative pulmonary complications. Not smoking on the day of surgery reduces nicotine stimulant effects on CVS and improves the oxygen-carrying capacity of haemoglobin.

- The ASA physical status classification

This correlates with postoperative mortality. The higher the ASA physical status of a patient is, the greater the postoperative morbidity or mortality.[1]

ASA Physical Status	**Definition**
ASA I	Normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life
ASA V	A moribund patient who is not expected to survive without surgery
ASA VI	A brain-dead patient for organ harvesting

ASA Physical Classification System. 2020. ASA Physical Classification System. Accessed January 30 2023. https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

- Consent

Consent must be obtained in advance before any premedication and must be in writing on the prescribed consent form. It must be informed and voluntary. Any person giving consent must be legally competent, defined as a person 18 years or older. A person 14 years or older can sign consent for termination of pregnancy/contraception, and married persons under 18 may consent for themselves and their children for surgical procedures. Natural or legal parents must sign for minors.

Practice Examination Questions

1. Regarding preoperative assessment of surgical patients (10 marks)
    a. List five benefits of carrying out a preoperative assessment (5 marks)
    b. List the five components of preoperative assessment (5 marks)

2. The American Society of Anesthesiologists' Physical Status Classification System is a perioperative risk classification system
    a. Classify ASA physical status
    b. What is the ASA physical status of a 45-year-old male patient with a ruptured abdominal aneurysm?

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CHAPTER 3

THE ANAESTHETIC MACHINE

K U TOBI & L NANYALO-NASHIMA

The anaesthetic machine is a device for delivering a continuous flow of anaesthetic gases.

The Boyle's Machine

Henry Edmund Gaskin Boyle invented the Boyle's Machine in 1917, the prototype of modern anaesthetic machines. The modern anaesthesia machine is divided into three parts:

1. The **high-pressure system** receives gas at cylinder pressure, e.g.:
- Cylinder pressure gauge, e.g. a Bourdon's gauge, which measures cylinder pressures. This flexible tube straightens when exposed to gas pressure causing a gear mechanism to move a needle pointer.
- Cylinder pressure regulators: these reduce the high pressures delivered by gas cylinders to the anaesthetic machine. In addition, they help to maintain constant pressure and reduce the need for high-pressure tubing. Pressure regulators are gases-specific and often have pressure relief valves to prevent excessive pressure.
- Others are the yoke block and hanger yoke.

2. The **intermediate pressure system** receives gases at low, relatively constant pressures, e.g.:
- Oxygen flush valve: this allows oxygen to bypass the fresh gas flow to the patient. It allows 100% oxygen to be delivered to the patient. It is helpful in emergencies such as patient desaturation.
- Ventilators: these are devices that provide positive pressure ventilation to anaesthetized patients. Examples include Manley ventilators and bag-squeezers, which employ mechanical or pneumatic force to intermittently compress the bag or bellows.
- Relief valves (or expiratory valves) vent excess gas to the atmosphere or a scavenging system.

- Other components include the pipeline inlets and oxygen pressure-failure devices.

3. The **low-pressure system** includes components distal to the flowmeter, e.g.:

- Flowmeter tubes: these measure gas flow from the anaesthetic machine, breathing circuits and gas cylinders. They may be divided into a constant orifice, variable or constant pressure, and variable orifice flow meters. An example of a constant pressure variable orifice flow meter is the rotameter.
- Vaporisers are devices for adding accurate and safe concentrations of anaesthetic vapour to a stream of carrier gas. They are classified mainly into two types, namely plenum and draw-over vaporisers.
- Other components include valves and the common gas outlet.

Safety features in the modern anaesthetic machine are:

- *Colour coding system*, e.g. oxygen is a black body, white shoulder, CO2 is grey, NO2 is blue, while nitrogen is black.
- *Agent-specific vaporiser*: a vaporiser will accept only a spout tip with an index groove carved into its side. The vaporiser, the spout and the bottle are also colour coded for the inhalational agent.
- *Safety pressure-relief valve*: this is designed to prevent rupture of the cylinder should the pressure within it rise rapidly above working pressure. It works based on a metal disc that ruptures at high pressure, an alloy with a relatively low melting point or a spring-loaded one-way valve that yields to high pressure.
- *Safety valve for oxygen:* this is a mechanical device designed to interrupt the flow of nitrous oxide and other inert gases to the anaesthetic circuit once oxygen supply pressure falls to 25ppsi. It is achieved by either shutting off the supply of all gases or venting them into the atmosphere at a point distal to the flowmeters.
- *Alarm system*, e.g. oxygen failure alarm: an alarm sounds a high-pitched warning for at least 7 seconds when the oxygen supply fails.
- *The diameter-index system* consists of a female component with two concentric bores that will mate with a corresponding male component with two concentric diameters. The diameters are specific for each gas.
- *Exclusive vaporiser control:* prevents more than one vaporiser from being switched on simultaneously. Once the control of one vaporiser is on, the others are automatically locked in the off position.

- *Analyser*, e.g. oxygen analyser: analyses the oxygen concentration delivered to the FGF. It emits an audible alarm and a visual signal when the oxygen concentration of the gas mixture falls below 21%.
- *Flowmeter control for oxygen*: the oxygen flowmeter feeds downstream from the others so that oxygen is lost only if there is a leak in its flowmeter tube. In addition, the oxygen flowmeter control knob is colour coded, has the chemical formula for oxygen affixed to its face and has a profile unique to sight and touch. Also, it is the most accessible of all the flowmeter controls.
- *Pin-index system:* this is incorporated into the cylinder valve block, and it is designed to prevent the attachment of a cylinder to the wrong inlet on the anaesthetic machine. It is achieved by the presence of two holes just below the exit port of the valve block. These holes are matched by two corresponding pins on the yoke of the anaesthetic machine. Two exclusive loci of holes and pins have been assigned to each gas: for oxygen it is 2:5 and for nitrous oxide it is 3:5.

Basic anaesthesia machine-check:

- Switch on the anaesthetic machine, turn off all flows and connect the breathing system
- High-pressure system:
    - Oxygen cylinder pressure, should be > 5,000 kPa
    - Oxygen monitor in-room air – calibrate to 21% and place at the common gas outlet
    - Open oxygen flowmeter @ 2l/min, oxygen monitor should rise
    - Check oxygen flush to ensure that the valve/s are not sticking
    - Disconnect oxygen supply and check that N2O flow ceases – (i.e. oxygen failure cut-off switch is functional).
- Intermediate-pressure system:
    - Check all pipeline gauge pressures
- Low-pressure system:
    - Assemble the breathing system correctly
    - Occlude the breathing system, close the APL valve and perform a positive pressure leak test of the circle and machine
    - Check the APL valve pressure release
    - Check soda-lime is filled