ASSESSMENT OF THE PATTERN AND SAFETY OF ANESTHETIC PRACTICE

in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia

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A RESEARCH THESIS SUBMITTED TO THE DEPARTMENT OF ANESTHESIOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR SPECIALTY CERTIFICATE IN ANESTHESIOLOGY

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Abstract

Background: Anesthesia services in many low and middle income countries are extremely poor. Literatures demonstrate a serious, sustained lack of safe anesthesia for surgery. The unacceptably high avoidable mortality rates associated with anesthesia in low income countries are related to airway problem, anesthesia in the presence of hypovolemia, poor technique, lack of training and supervision of non-physician anesthesia care providers and lack of monitoring, drugs and equipment. On the other hand, anesthesia related risk in developed nations is low as result of improvements in training, equipment and drugs and the introduction of mandatory monitoring standards and protocols such as pulse oximetry and capnography. International standards play an important role in guiding the development of anesthesia services. If the safety of anesthetic services is to be improved, wide adoption of these standards by ministries of health and local professional societies is imperative.

Methods: A cross-sectional descriptive study design was employed for a 6 weeks' period of time from October 1st, 2017 to November 14th, 2017 at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia. A structured checklist was used to gather data regarding the availability of facilities, equipment and drugs. A structured, self-administered questionnaire was used to gather data regarding patterns and safety of peri-anesthetic care and monitoring. A series of unstructured in-depth interviews were conducted to key-informants to gather data regarding the work force capacity, accessibility of equipment and drugs, and issues that were not addressed by the other data collection tools.

Results and Discussion: Anesthesia care at Tikur Anbessa Specialized Hospital was carried out by 44 physician and 47 non physician anesthesia care providers. There was a promising rise in the numbers of anesthesiology residents in recent years. In addition to routine anesthetic care service in the operating rooms, additional anesthesia services were also provided in a gastrointestinal endoscopy suite, MRI suite and pediatric procedure suite. There was a significant resource limitation with regards to airway and other anesthesia equipment and devices used for monitoring. Drugs' availability was relatively good. The majority of perioperative anesthetic care practices with some exceptions were equivalent to minimum mandatory standards (level 1/basic).

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List of Acronyms

BSc. Bachelor of Science

ECG Electrocardiography

FG French Gauge

G Gauge

ICU Intensive Care Unit

LMA Laryngeal Mask Airway

LMICs Low and Middle Income Countries

MSc. Master of Science

NIBP Non-invasive Blood Pressure

NPACP Non Physician Anesthesia Care Provider

OR Operating Room

p.s.i.g. pounds per square inch gauge

PACP Physician Anesthesia Care Provider

POMR Peri-Operative Mortality Rate

TASH Tikur Anbessa Specialized Hospital

WFSA World Federation of Societies of Anesthesiologists

WHO World Health Organization

Introduction

Background

The concise oxford dictionary (10th ed., 2000) defines safe as "protected from or not exposed to danger or risk; not likely to be harmed or lost; not causing or leading to harm or injury." Anesthesiology has been a leader in patient safety since the very beginning (Enright, 2013). It has participated in systematic attempts to improve patient safety since as early as 1932, in the setting of standards for color codes of medical gas cylinders as early as 1932 (Mellin-Olsen, Staender, Whitaker, & Smith, 2010)).

With regard to risks that are directly related to anesthesiology, surrogates of safety such as morbidity and mortality data must be considered. In developed countries, anesthesia is associated with low risks for serious morbidity and mortality with figures as low as one in 185000. On the other hand, the avoidable anesthesia-associated mortality in developing countries has been estimated at 100–1000 times the rate reported in developed countries. Substandard anesthesia infrastructure and shortage of physician and non-physician anesthesia care providers in low-income countries contribute to poor patient outcomes in addition to limited access to emergency and essential surgery. Anesthesiology, as a specialty is a pioneer regarding the safety movement for patients and in the establishment of standards for the safety of its practice. In 2009 the WFSA's general assembly endorsed the International standards for a safe practice of anesthesia and it was ratified on March 19th, 2010 G.C. Organization (2009)

In 2010, the World Federation of Societies of Anesthesiologists (WFSA) published standards intended to improve the safe practice of anesthesia worldwide, even in resource-limited settings. These guidelines outline "highly recommended" "recommended," and "suggested," aspects of hospital infrastructure, supplies, and professional standards with basic, intermediate and optimum respectively of level of care. The guidelines also provide a designation of 3 levels of hospital care as small hospital, district/provincial hospital, and referral (tertiary care) hospital. Each level is expected to exceed the standards outlined for the preceding level. (Merry, Cooper, Soyannwo, Wilson, & Eichhorn, 2010) Universal adoption of these standards is of no question if the safety to anesthetic services is to be improved. This objective has been achieved in many of the affluent countries of the world. The scenario, however, is different in resource poor nations which lag far behind even to achieve the basic level of care. There is much to be done before these countries can achieve the international standards and improve patient safety in anesthesia. (Lanier, 2006)

Statement of the Problem

Surgical conditions constitute 11%–32% of global disease burden. Unfortunately, adequate treatments are lacking in low- and middle-income countries (LMICs). Approximately 313 million operations are done annually, but only 6% are performed in countries where the poorest one-third of the population resides; consequently, 5 billion people lack access to quality care. Anesthesia is an essential component of surgery, and research describing anesthesia capacity in LMICs paints a striking picture. (Meara JG, AJ, & al, 2015) The anesthesia workforce is in crisis, with physician-to-population densities ranging from 0 to 4.9 per 100,000. (Hoyler M, Finlayson SR, McClain CD, Meara JG, & L., 2014) Education, infrastructure, equipment, and medications are also in short supply. (LeBrun DG, Chackungal S, & Chao TE, 2014) Perioperative mortality rates (POMRs) are as high as 1 per 74 anesthetics. (Knowlton LM et al., 2013) It is highly likely that similar problems prevail in Ethiopia like most other countries with low income. To meaningfully address these problems an understanding of local circumstances is first required. Unfortunately, there are no published literatures regarding the adoption and implementation of the minimum international standards, anesthesia capacity and anesthesia related morbidity and mortality in the country or the institution. The results of this study generated data on how the safety and pattern of anesthetic practice is in one of the biggest tertiary hospitals in Ethiopia i.e. Tikur Anbessa Specialized Hospital (TASH) and whether they conform to the international minimum standards.

Literature Review

In the affluent countries of the world anesthesia is associated with low risks for serious morbidity and mortality. Contemporary estimation of avoidable mortality related to anesthesia in Australia and Europe range from about 1 in 10,000 to 1 in 185000. (Organization, 2009) In contrast, the avoidable anesthesia associated mortality in low income countries is estimated to be one hundred to one thousand folds higher. For instance, the rate was about 1 in 150 in Togo in 2005. (Ouro-Bang'na Maman AF, 2005)

Estimation of mortality due to anesthesia is problematic: most reporting is voluntary, the denominator is seldom a reliable figure, sedation is not routinely captured, the case mix to which the figures are applied is usually unknown, and there is no agreed definition of anesthetic mortality. Even when clearly defined, it may be difficult to separate it from causes related to the operation and the patient's underlying condition. (Organization, 2009) There are, however, few reliable data to determine the true rate of mortality associated with anesthesia. In the Netherlands, Arbouset et al. found that, between 1995 and 1997, the incidence of anesthesia-related deaths within 24 hours of a procedure was 0.14 per 100,000 procedures (8.8 per 100 000 for only partly anesthesia-related deaths). In France, Lienhart et al. reported that, in 1999, anesthesia-related in-hospital mortality rate was 0.7 per 100,000 and partially anesthesia-related death rate was 4.7 per 100 000; 42% of deaths occurred within 24 hours of the procedure. These rates were even lower for the American Society of Anesthesiology (ASA) I patients, in whom mortality solely or partially related to anesthesia was found to be 0.4 per 100,000. The study from Australia corroborates these findings; Gibbs and Borton found for the period 2000–2002 an anesthesia-related mortality rate within 24 hours of anesthesia of 0.55 per 100 000. In the United States, between 1999 and 2005, Li et al. reported an anesthesia-related death rate of 1.1 per million population per year and 8.2 per million hospital surgical discharges. The authors estimated that the mortality risk of anesthesia for surgical inpatients was 0.82 in 100 000 cases, which provides further support for the data from Australia and Europe. Overall, the mortality risk from complications and adverse events of anesthesia today appears to lie at approximately 1 in 100,000 cases for Australia, Europe and the United States. (Mellin-Olsen et al., 2010) The rate of mortality attributable solely to anesthesia in healthy patients undergoing minor surgical procedures is likely to be at the lower end of this range. The higher estimates tend to reflect mortality to which anesthesia is thought to have contributed, often in patients with significant comorbidity who are undergoing major surgery.

There is good reason to believe that anesthesia-related risks in the developed world have decreased significantly over the past two decades due to improvements in training, equipment and medications and the introduction of standards and protocols. Mandatory monitoring standards, in particular pulse oximetry and capnography, are considered particularly important. (Organization, 2009)

On the other hand, the avoidable anesthesia-associated mortality in developing countries has been estimated at 100–1000 times the rate reported in developed countries. In published series, avoidable mortality associated with anesthesia was as high as 1:3000 in Zimbabwe (McKenzie, 1996), 1:1900 in Zambia (Heywood AJ, Wilson IH, & JR, 1989), 1:500 in Malawi (Hansen D, Gausi SC, & M., 2000) and 1:150 in Togo (Ouro-Bang'na Maman AF, 2005). Mortality associated with anesthesia, particularly in the developing world, is primarily related to two causes: airway problems and anesthesia in the presence of hypovolemia. Reports from Nigeria and Malawi demonstrate that obstetric patients account for 50% of the anesthesia-related deaths in developing countries. These studies also indicate that poor technique and lack of training, supervision and monitoring contribute to the high mortality. The potential for professionals to learn lessons about avoidable deaths is limited in many hospitals, as few such events are recorded or formally discussed. (Enohumah KO & CO., 2006 ; Hansen D et al., 2000)

Although the situation varies widely throughout the world, anesthesia services in many countries are extremely poor, particularly in rural areas. For the most part, deficiencies go unrecorded, as there are few systematic reviews of anesthetic conditions and practice. The methods used in these studies are comparable, and they demonstrate a serious, sustained lack of safe anesthesia for surgery. These unacceptably high figures are indicative of a deteriorating situation. The lower rates of anesthesia related risk in the developed nations is as result of improvements in training, equipment and drugs and the introduction of mandatory monitoring standards and protocols such as pulse oximetry and capnography. (Organization, 2009)

The unacceptably high avoidable mortality rates associated with anesthesia in low income countries are related to airway problem, anesthesia in the presence of hypovolemia, poor technique, lack of training and supervision of non-physician anesthesia care providers and lack of monitoring, drugs and equipment. (Enohumah KO & CO., 2006 ; Hansen D et al., 2000)

The presence of a trained anesthesia care provider is one of the most important factors determining the level and quality of health care service administered by an institution. One of the basic recommendations of guidelines to practice is the presence of a trained anesthesia provider. (Merry et

al., 2010) There is a critical shortage of trained anesthesia care providers (both physician and non-physician) in low income countries. For instance, a study done by Linden et al. showed that in Uganda, the anesthesiologist to population ratio was 1 to ~2,000,000 and out of 14 district level hospitals surveyed only two had anesthesiologists. There were two mid-level (clinical officers and anesthesiology assistants) anesthesia care providers on average per hospital. Out of the hospitals, two had only anesthesiology assistants and two lacked any provider at all. (Linden AF, 2012) The situation in Rwanda is similar with Uganda's experience with only two expatriate anesthesiologists working in the district level hospitals. (Notrica MR, 2011) A study done by Speigel et al. in Mongolia showed there wasn't any anesthesiologist at all in 44 of the primary health care centers. In five of these centers anesthesia care was provided by general practitioners and in 10 of them it was provided by non-physician anesthesia care providers. (Spiegel DA, 2011) According to data from WFSA, in Ethiopia currently there are a total of 51 anesthesiologists, 350 nurse anesthetists and 400 'other' anesthesia providers (BSc. and MSc.). Anesthesiologist to population ratio in Ethiopia is similar to that of Uganda, 1 to ~2,000,000. (WFSA)

Despite clinical officers (or their equivalents) provide the back bone of anesthesia service in many countries there are significant limitations to their knowledge, skills and training. In order to increase the total number of anesthesia care providers (both physician and non-physician) extensive work has to be done in recruiting individuals to join the specialty; improve the education in anesthesia and devise a way to increase their retention in their home countries. (Enright, 2013)

Being the major anesthesia care providers in the non-urban areas, attention and support are required to increase the number of well-trained clinical officers and nurse specialists in anesthesia. The WFSA is active in providing training opportunities in many areas of the world. Training given in Bangkok, Thailand for trainees from surrounding countries such as Laos, Myanmar, Mongolia and Vietnam is a typical example. (Enright, 2013)

A number of residency and sub specialty programs are also being actively supported by the WFSA and overseas societies of anesthesia and university departments such as the Canadian Anesthesiologists' Society and American Society of Anesthesiologists in Rwanda, the Irish College of anesthetists in Malawi and the AAGBI in Uganda. (Organization, 2009)

Retention of trained providers is also a huge problem in developing countries. While external losses of physicians are greatest, there are frequent internal losses of trained anesthesia care providers to other fields of work and from rural to urban centers. The impacts of these losses are enormous on patient care

and the countries' economies. Health ministries in low income countries must come up with plans to develop carrier pathways that offer satisfaction and challenge to all their health workers. (Brouillette et al., 2017)

The other problem of care providers regarding the specialty is limited or no access to CMEs and workshops. As a result, a large percentage of trained anesthesia providers don't have the opportunity to read a journal, are unaware of standards and guidelines to practice and have been unable to update/upgrade their techniques from what they have learned during training. And when opportunities become available, it is difficult for clinical officers or even anesthesiologists to benefit from them because of long distance and transportation difficulties, heavy workloads and difficulty in taking a leave of absence. The establishment, growth and maturation of local, regional and national societies of anesthesia need to be realized if a significant progress is to be made in this area. (Enright, 2013)

International standards play an important role in guiding the development of anesthesia services and should be adopted by ministries of health and local professional societies. Anesthesiology has played a pioneering role in the patient safety movement and in the establishment of standards for a safe practice. Anesthesiologists first codified the concept of 'patient safety' in 1984 at the inaugural meeting in Boston (United States) of the International Committee on Preventable Anesthesia Mortality and Morbidity. The first organization devoted to the concept of patient safety was the Anesthesia Patient Safety Foundation, created in the United States in 1985. This independent organization was the result of considerable effort on the part of the medical professionals involved, with the support of related industries and government regulators. The original "Harvard monitoring standards" for intraoperative anesthesia care were the first formally published, detailed medical standards of practice. They stimulated the American Society of Anesthesiologists to adopt their 'Standards for Basic Intraoperative Monitoring' in 1986. This initiative encouraged a cascade of standards, guidelines and protocols by professional anesthesiology groups and societies around the world. In 1989, the International Task Force on Anesthesia Safety was established, comprising leaders in anesthesia patient safety in nine countries. After two years of extensive work, the Task Force published the first International standards for a safe practice of anesthesia. The document consisted of four printed pages and contained an outline of both general standards for the profession and practice of anesthesiology and specific standards for peri-anesthetic care and monitoring. Because of the variation in resources available in different locations around the world, the standards for equipment required for peri-anesthetic care and monitoring were classified into three levels: basic, intermediate and optimal, to correlate realistically with available local

resources. The essential care and monitoring concepts were universal and applicable everywhere, from the most isolated, resource-challenged locations in the developing world to the most economically and technologically advanced capitals. Ability to implement the concepts differed greatly, however. One focus was to help provide more anesthetists in disadvantaged areas and to securer sources for improving anesthesia quality and safety. The World Federation of Societies of Anesthesiologists formally adopted these international standards at its congress in The Hague in June 1992 and recommended them to all its member societies. The International standards for a safe practice of anesthesia and 10 supporting documents were published as supplement to the European Journal of Anesthesiology in January 1993. The work of the International Task Force underpins much of the current work in anesthesia safety. At the most recent meeting of the World Federation of Societies of Anesthesiologists, the 1992 standards were revised and updated and subsequently endorsed by the General Assembly during the 14th World Congress of Anesthesiologists in Cape Town, South Africa, on 7 March, 2008. The older standards had not, however, been actively promoted or endorsed globally. The main addition to the previous international standards is the requirement for pulse oximetry as an essential component of patient monitoring. Pulse oximetry is used almost universally in industrialized countries during the administration of anesthesia. While strong, unequivocal evidence from a randomized clinical trial is lacking, few anesthesia providers would willingly do without this device. If the safety of anesthetic services is to be improved, wide adoption of the standards is imperative. (Organization, 2009)

Objectives

General objective

The general objective of this study is to assess the pattern and safety of anesthetic practice in TASH with respect to accepted international standards.

Specific objectives

The specific objectives of this study are:

- to assess the capacity of the anesthesia workforce in TASH
- to assess the availability and/or functionality of the anesthesia related facilities, equipment and drugs in TASH
- to assess the practice patterns and safety of monitoring during anesthesia in TASH
- to assess the practice patterns and safety of pre-anesthetic care in TASH
- to assess the practice patterns and safety of post-anesthetic care in TASH

with respect to accepted international standards.

Research question

How is the pattern and safety of anesthetic practice in Tikur Anbessa Specialized Hospital with respect to accepted international standards?

Methods

Study Setting and Period

This study was conducted at TASH, Addis Ababa Ethiopia which is the largest tertiary level hospital in Ethiopia.

Study Design

A cross-sectional descriptive study design was employed for a 6 weeks' period of time from October 1st, 2017 to November 14th, 2017.

Study Population

All eligible BSc. anesthetists and second and third year anesthesiology residents were included in the study.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Being a BSc. Anesthetist, employed and working at TASH at the time of the study.
- Being a second or third year anesthesiology resident in the department of anesthesiology at the time of the study.

Exclusion Criteria

- Being unavailable during the data collection period.

Data Collection Tools and Procedures

- To gather data regarding the availability of facilities, equipment and drugs, a structured check list with open comment section (adapted and modified from WFSA's International Standards for a Safe Practice of Anesthesia 2010) was used.
- To gather data regarding patterns and safety of peri-anesthetic care and monitoring, a structured questionnaire modified from WFSA anesthesia capacity tool was used.
- Two second year anesthesiology residents collected the data after being instructed by the principal investigator.
- To gather data regarding the work force capacity, accessibility of equipment and drugs, and issues that were not addressed by the other data collection tools, a series of unstructured in-depth interviews were conducted to a total of seven key-informants including consultants working in the department (n=2), the anesthesia coordinator (n=1), the head of the OR pharmacy (n=1), and final (third) year anesthesiology residents (n=3).

Study Variables

Relevant study variables were derived from a review of WFSA's International Standards for a Safe Practice of Anesthesia 2010.

The study variables included:

- Anesthesia workforce capacity i.e. professional status and residency training.
- Availability and/or functionality of anesthesia facilities, equipment and medications.
- Peri-anesthetic care including pre-anesthetic care, intraoperative monitoring and post anesthesia care.
- Pre-anesthetic care including preanesthetic evaluation, pre-anesthesia checks.
- Intraoperative monitoring (oxygenation, airway and ventilation, heart rate and rhythm, blood pressure, temperature, neuromuscular function, depth of anesthesia monitoring).

- Post anesthesia care including post anesthesia care facilities, personnel, monitoring and pain relief.

Data processing and analysis

- Data was entered using Microsoft Word, 2010.
- Calculations for descriptive statistics were performed using Microsoft Excel 2010.
- A narrative format was used to describe the result and analysis of the study.

Data quality and control

Pretest of the self-administered, structured questionnaire modified from WFSA anesthesia capacity tool was conducted on five anesthetists outside the study area prior to the actual data collection to test the accuracy of the questionnaire to collect the intended data.

Revision of the collected data and checks for completeness before data entry were conducted by the principal investigator.

Ethical Consideration

Clearance to undertake the study was obtained from the institutional review board of AAU, CHS.

Consent to participate in the study was obtained from each participant. Confidentiality and privacy were maintained.

Dissemination of results

The findings of the study were submitted to the department of anesthesiology.

The manuscript of the research was prepared to be submitted to the central library and appropriate journals for possible publication and to be presented to scientific conferences.

Results

TASH anesthesia care was carried out by 44 physician and 47 non physician anesthesia care providers. Table 1 below shows the anesthesia work force of TASH. Anesthetic practice in TASH was physician led. There were 8 consultant anesthesiologists practicing at TASH who supervised the anesthesia care provided by anesthesiology residents and anesthetists. However their number was too few to provide adequate supervision of care while allowing time for teaching, research and administrative responsibilities. A result of which was anesthesiology residents and anesthetists managing many patients without the full supervision of an anesthesiologist.

At TASH, in addition to routine anesthetic care service in the operating rooms, additional anesthesia services were also provided in a gastrointestinal endoscopy suite, MRI suite and minor pediatric procedure suite. Operating rooms were covered by anesthesiology residents, who rotated monthly to sub-specialty anesthesiology O.R. attachments and anesthetists who were assigned to a specific O.R. daily based on each day's schedule. In addition, undergraduate (BSc.) and postgraduate (MSc.) anesthesia trainees on formal anesthesia attachment to TASH were also intermittently involved in providing anesthesia care under the supervision of staffs. Anesthesia care providers at TASH and the rest of the country participated in two national professional organizations namely the Ethiopian Society of Anesthesiologists Professional Association and the Ethiopian Society of Anesthetists.

Table 1 Anesthesia Work Force in Tikur Anbessa Specialized Hospital

Table 1. Anesthesia Work Force in Tikur Anbessa Specialized Hospital

Anesthesia Care Providers	Number of individuals
Physician Anesthesia care providers (PACPs)	
Consultant Anesthesiologists	8
Anesthesiology Residents	36
First year	18
Second year	7
Final year	11
Sub-total	**44**
Non Physician Anesthesia care providers (NPACPs)	
M.Sc. Anesthetists	11
B.Sc. Anesthetists	36
Sub-total	**47**
Total number of anesthesia care providers	**91**

Table 2 Facilities Available at TASH

Table 2 WFSA-Recommended (and other) Facilities Available at TASH

- Continuous electricity service with reliable back-up generators in case of power outage
- Intermittent supply of clean running water
- Reliable oxygen source (2000 p.s.i.g. oxygen cylinders)
- Fourteen functional operating theaters each equipped with electronic tilting tables and modern anesthesia ventilators (Aeonmed) with reliable electric power source with manual override
- Major/Advanced surgical procedures (Level 3 equivalent and higher) including:
    - Head and neck, neurologic, pediatric and neonatal, urologic, gynecologic, thoracic, cardiac, gastrointestinal, vascular, endocrine and orthopedic surgeries.
- One general intensive care unit with 16 beds (12 adult and 4 pediatric) each equipped with monitors and mechanical ventilators
- One cardiac intensive care unit
- Hemodialysis unit
- Pre-anesthetic clinic (open four out of five days)
- Two designated post anesthesia recover facilities alongside the operating rooms
- Blood bank

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital

Table 2 above shows the different facilities available at TASH. Surgery and anesthesia were performed in 14 operating rooms divided into three operating suites: the 'Major' O.R. (as informally called) located on the fourth floor of the main building of TASH comprised of 9 operating rooms; the 'Orthopedics' O.R. located on the third floor of the orthopedic rehabilitation center building comprised of four operating rooms; and the 'Obstetrics' O.R. located adjacent to the labor ward at the sixth floor of the building comprised of one operating room. Each O.R. was equipped with an electronic tilting table and a number of O.R. lights. A modern anesthesia ventilator (mainly Aeonmed) with a reliable electric power source and a manual override system was available in all of the O.Rs. Waste gas scavenging systems however were poorly constructed. They were made of breathing circuits interconnected with adhesive tapes and lying inside the rooms even while anesthesia is going on. There were other rooms were these circuits were taken out to the outside by in connection with a makeshift tubing. Continuous supply of electricity was available most of the time and reliable back-up generators were available that bridged power outage episodes. Access to clean running water was available but the supply was intermittent and the facility's back up storage was unreliable. Oxygen was supplied to the hospital as 2000 p.s.i.g. cylinders and the

supply to the O.R. was adequate. Each anesthesia ventilator was connected with these cylinders and whenever a cylinder runs out of oxygen there would be a replacement cylinder at the gates of the operating suites.

There was a designated room for pre-anesthetic clinic at the first floor of the building which also doubled as an outpatient pediatric surgical clinic by a non-overlapping arrangement. It ran four out of five days from one thirty to five p.m. The pre-anesthetic clinic served as a gate way through which elective surgical patients passed for preoperative anesthetic evaluation, work up and medical optimization before admission to the hospital.

There were also two designated post-anesthesia care facilities in close proximities to the 'Major' and 'Orthopedics' O.Rs equipped with equivalent numbers of patient beds to the operating rooms. There wasn't a post-anesthesia care facility for post op patients from the 'Obstetric' O.R. Once awake, patients were transferred to the labor or obstetrics wards where they were inadequately monitored.

Blood bank service was available in the hospital which supplied blood to both elective and emergency surgical patients. Whole blood, packed red blood cells, fresh frozen plasma and platelets were inconsistently available at the blood bank which faced severe shortage problems at times. During the study period there was one episode of severe shortage of blood and blood products which resulted in cancellations of many elective procedures for two weeks. The shortage problems were solved soon after a blood donation campaign was conducted in the hospital.

Another facility running under the department of anesthesiology at TASH was the surgical intensive care unit (ICU) which shared half of the 12 beds with the medical ICU. There was a designated pharmacy in the ICU. Each of the beds was equipped with blood pressure, saturation, heart rate and rhythm monitors and a mechanical ventilator.

Table 3 below shows the availability of airway management equipment as recommended by WFSA. The majority of airway management equipment consisted of incomplete sets of instruments/items. None of the operating rooms were fully equipped with a complete set of oral airways, facemasks, LMAs, endotracheal tubes, laryngoscopes and stylets or bougies. Consistently available instruments were suction catheters and electronic suction machines (which are also usually shared with the surgeons so there wasn't a constant access).

Surprisingly although not supplied by TASH, there were a video laryngoscope (glidescope) and external power- and battery- operated flexible fiber optic bronchoscopes available in the department of anesthesiology (donated by different affiliated anesthesiology departments from abroad at the time of

their visits). These instruments were widely being used in the management of patients with difficult airways and for lung isolation during thoracic surgeries. A point of concern regarding these instruments raised by providers was the unavailability of skilled professionals at the institution to maintain and repair them should malfunctions occur. Considering these instruments would not be ordinarily supplied by the hospital, any malfunction would affect the safe handling of patients with difficult airways.

Table 3 Airway Equipment Availability at TASH

Table 3 WFSA-Recommended[1] Airway Equipment Availability at TASH

Equipment	Availability[2]
Level 1	
Self-inflating bags with masks	Available
Airways and endotracheal tubes	Available
Laryngoscopes	Available
Bougies/stylets	Available
Suction (Manual)	Unavailable
Suction catheter (size 16)	Available
Level 2 (each one set/item per O.R.)	
Oral airways (sizes 000 - 4)	Inconsistent
Nasal airways	Unavailable
Face masks (sizes 00 - 5)	Inconsistent
Self-inflating bags	Available
Endotracheal tubes (sizes 3.0 - 8.5 mm)	Inconsistent
Laryngoscopes Macintosh Blades (no. 1 - 4)	Inconsistent
Stylets and bougies	Inconsistent
Suction (Manual or Electric)	Available
Suction catheter (size 16)	Available
Magill Forceps	Inconsistent
Level 3 (Same as level 2 plus the following)	
LMAs (sizes 2, 3, 4) 3 sets per O.R.	Inconsistent
Suction (Electric or Pneumatic)	Available
Yankauer suckers	Unavailable
Disposables for suction machines	Unavailable

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital; LMA, Laryngeal mask airway;
1 All equipment should be appropriate for patients' age and size.
2 Equipment were labeled "available" if observed in >90%, "inconsistent" if observed in 10%–90%, or "unavailable" if observed in <10% of operating rooms.

Table 4 Equipment Availability in TASH

Table 4 WFSA-Recommended Equipment Availability in TASH	
Equipment	**Availability[1]**
Level 1	
Oxygen concentrator with draw over vaporizer with hoses	Unavailable
IV infusion/drug injection equipment	Available
Level 2	
Reliable Oxygen source	Available
Vaporizer(s), hoses and valves	Available
Defibrillator (one per O.R. suite)	Unavailable
Pediatric anesthesia system	Available
Spinal needle (22 and 25 G)	Inconsistent
IV cannula (16, 18, 22, 24 G)	Available
IV administration set (adult and pediatric)	Available
Adult and pediatric resuscitator sets	Unavailable
IV pressure infuser bag	Inconsistent
Work surface and storage	Available
ECG electrodes	Unavailable
Examination gloves	Unavailable
Sterile gloves (sizes 6 - 8)	Available
NG tubes (sizes 10 - 16 FG)	Available
Batteries (size C)	Unavailable
Level 3 (Same as level 2, with the following additions)	
Anesthesia ventilator	Available
Ventilator circuits	Available
Infusion pumps (2 per bed) with giving sets	Unavailable
Electric warming blanket	Unavailable
Electric overhead heater	Unavailable
Infant incubator	Unavailable
Disposables for capnography and oxygen analyzer	Unavailable

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital; NG, nasogastric; IV, intravenous.
1 Equipment were labeled “available” if observed in >90%, “inconsistent” if observed in 10%–90%, or “unavailable” if observed in <10% of operating rooms.

Table 4 above shows the availability of other anesthesia and related equipment. Basic equipment such as spinal needle, ECG electrodes, examination gloves and adhesive tapes were not available at TASH. Equipment for resuscitation such as defibrillators, IV pressure infuser bags, adult and pediatric resuscitator sets were also not consistently or available at all. In terms of patient warming devices, despite the lack of electric warming blankets, overhead heaters and infant incubators as recommended by the WFSA, there were two conduction heaters available in the pediatrics O.R. where their presence was of immense importance. In addition, there was also another overhead heater in the post anesthesia care room adjacent to the "major" O.R. Small children and neonates were warmed with this heater postoperatively.

Table 5 Monitors' availability at TASH

Table 5 WFSA-Recommended monitors' availability at TASH

Monitor	Availability [1]
Pulse oximeter	Available
Automatic non-invasive blood pressure	Available
Electrocardiograph	Available
Oxygen analyzer with low-concentration/failure alarm	Available
Circuit disconnect alarm	Available
Volume of inspired/expired gas	Available
Capnograph	Unavailable
Thermometer	Unavailable
Sphygmomanometer	Unavailable
Nerve stimulator	Unavailable
Concentration of inspired/expired anesthetic analyzer	Unavailable

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital

1 Monitors were labeled "available" if observed in >90%, "inconsistent" if observed in 10%–90%, or "unavailable" if observed in <10% of operating rooms

Table 5 above, shows the availability of WFSA recommended monitors in TASH. Pulse oximeter, automated non-invasive blood pressure measuring device, electrocardiograph, capnograph, and thermometer were found all combined in one single monitor. Even though pulse oximeters were available in all of the operating rooms, malfunctioning and unavailability of pediatric sized and spare probes were significant issues. Providers frequently used adult probes on children and neonates with difficulties. Automated non-invasive blood pressure (NIBP) monitors were also available through-out the operating rooms. However there was shortage of ranges of different sized cuffs creating difficulties in getting reliable blood pressure monitoring for small children and thin and obese patients. Things were further

complicated by the lack of manual blood pressure measurement devices which could have been used in circumstances such as equipment malfunction. Electrocardiographs (ECG), like the other monitors were also available through-out the O.Rs. However, lack of ECG electrodes frequently interfered with ECG monitoring. To circumvent these problems, anesthesia care providers used lubricant jells and adhesive tapes to attach ECG leads to patients in order to get ECG monitoring. This technique was also hampered by frequent lack of jells and adhesive tapes. Another frequently faced challenge was lack of thermometer probes to get objective temperature records when indicated. Portable thermometers were not available either. Airway and ventilation monitoring with capnography was not possible because of lack of disposables for capnographs.

Table 6 below, shows the availability of WFSA recommended medications. Majority of the WFSA drugs were available at TASH. Intravenous anesthetics and sedatives (such as ketamine, propofol, thiopental, midazolam), inhalational agents (such as halothane, isoflurane), neuromuscular blocking drugs (such as pancuronium, vecuronium), anti-arrhythmic drugs (such as adenosine, amiodarone) and morphine were consistently available.

Table 6 Drugs' Availability at TASH

Table 6 WFSA-Recommended Drugs' Availability at TASH

Drug	Availability[1]
Level 1	
Ketamine	Available
Lidocaine 1% or 2%	Available
Diazepam	Available
Midazolam	Available
Pethidine	Unavailable
Morphine	Available
Epinephrine (Adrenaline)	Available
Atropine	Available
Level 2 (Same as Level 1 with these additions)	
Thiopental	Available
Propofol	Available
Suxamethonium	Available
Pancuronium	Available
Neostigmine	Available
Ether, halothane or other inhalation anesthetics	Available
Lidocaine 5% heavy spinal solution	Unavailable
Bupivacaine 0.5% plain	Available
Hydralazine	Available
Furosemide	Available
Dextrose	Available
Aminophylline	Unavailable
Ephedrine	Unavailable
Hydrocortisone	Available
Nitrous oxide	Unavailable
Level 3 (Same as Level 2 with these additions)	
Various modern neuromuscular blocking agents [a]	Available
Various modern inhalation anesthetics [b]	Available
Various inotropic agents [c]	Available
Various intravenous antiarrhythmic agents [d]	Available
Nitroglycerine for infusion	Available
Calcium chloride	Unavailable
Potassium chloride	Available

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital

1 Drugs were deemed "available" if present at the time of enquiry, "unavailable" if more than 3 months have elapsed since the last time they were present or if they have never been present at the hospital at all and "inconsistent" if they had been available within 3 months at the time of enquiry.

a, b, c, d Available drugs in these categories were a-vecuronium, b-isoflurane, c-dopamine d-adeonsine and amiodarone.

Perioperative anesthetic care

The following sub-section shows the result and analysis of data collected from the questionnaire administered to TASH anesthetists and anesthesiology residents to assess the pattern of perioperative care.

Descriptive statistics

All second year (n =7) and third year anesthesiology residents (n=11) and all BSc. anesthetists (n=36) were eligible for the study. Three of the third year residents and 4 of the BSc. anesthetists were excluded because of unavailability. The principal investigator (a third year anesthesiology resident) was also excluded.

A total of 46 anesthesia care providers were included. Response rate was 100%. Thirty percent (n=14) were anesthesiology residents and 70% (n=32) were BSc. Anesthetists. Sixty nine percent of the participants were females. Ninety five percent of the participants aged between 21-35 years old.

See Table 7 below, for the frequency of occurrence of variables as ‘always’, ‘sometimes’ or ‘never’ from responses generated by participants to the self-administered questionnaire assessing peri-anesthetic care.

Table 7 Results on perioperative anesthesia care, collected from questionnaires administered to anesthetists and anesthesiology residents.

	Variable	Response		
		Always	Sometimes	Never*
	1. Preanesthetic care			
1.1	Preanesthetic evaluation of patients by anesthesia care provider	13% (n=6)	87%	
1.2	Ensuring availability and functionality of equipment	82% (n=38)	18%	
	2. Intraoperative monitoring			
2.1	Oxygen supplementation of patients when under general anesthesia	100% (n=46)		
2.2	Verify integrity of oxygen supply	100% (n=46)		
2.3	Continuous monitoring of oxygenation by pulse oximetry	100% (n=46)		
2.4	Continuous monitoring of airway and ventilation by observation and auscultation or reservoir bag excursion	95% (n=44)		
2.5	Continuous monitoring of airway and ventilation with precordial, pretracheal, or esophageal stethoscope	5% (n=2)		
2.6	Continuous monitoring of heart rate and rhythm with electrocardiography	100% (n=46)		
2.7	Continuous monitoring of heart rate and rhythm by palpation, auscultation or pulse oximetry	15% (n=7)		
2.8	Continual (at least every 5mins) automated NIBP monitoring	100% (n=46)		
2.9	Neuromuscular function monitoring by clinical methods	100% (n=46)		
2.10	Depth of anesthesia monitoring by clinical observations	100% (n=46)		
2.11	Activated and audible signals and alarms	17% (n=8)	83% (n=38)	
	3. Post anesthesia care			
3.1	Monitor and accompany patients to the post anesthesia care unit	100% (n=46)		
3.2	Handover patients to post anesthesia care unit nurses	95% (n=44)	5% (n=2)	
3.3	Continuous monitoring with pulse oximetry	90% (n=41)	10% (n=5)	
3.4	Management of postoperative pain in the post anesthesia care facility	15% (n=7)	85% (n=39)	

* None of the participants selected 'never' as a response to any of the variables listed.

Analysis

A patient must always receive a formal/proper preanesthetic evaluation by an anesthesia professional. 87% of the participants responded to this scenario occurring as "sometimes" and only 13% of the participants responded "always".

Intraoperative oxygenation monitoring practices could be considered very good as all participants responded 'always' to the occurrence of oxygen supplementation of patients when under general anesthesia and verification of the integrity of the oxygen supply prior to anesthesia administration.

Intraoperative airway and ventilation monitoring practices at TASH could also be considered very good as all of the participants' response to the occurrence of continuous monitoring of airway and ventilation was 'always'; of these 95% used observation, auscultation or reservoir bag excursion and 5% used precordial stethoscopy.

Heart rate and rhythm monitoring practices intraoperatively could be labeled as very good as all participants responded 'always' to the occurrence of continuous heart rate and rhythm monitoring using ECG. In addition, 15% of the participants also responded 'always' to the occurrence of heart rate and rhythm monitoring using palpation and auscultation and/or pulse oximetry in addition to ECG monitoring.

Intraoperative blood pressure monitoring practices could also be labeled 'very good' as all participants claimed to always monitoring blood pressure continually (at least every 5minutes) using automated NIBP monitoring.

All participants also claimed to monitoring depth of anesthesia regularly using clinical methods as depth of anesthesia monitors such as end-tidal anesthetic gas concentration analyzer and electroencephalography are unavailable.

Temperature monitoring could be considered as not being measured in an objective way at all. 84% (n=39) of the participants claimed to compare patients' body temperature against theirs to monitor temperature.

Neuromuscular functioning was monitored using clinical methods alone as peripheral nerve stimulators -were unavailable. All participants claimed to 'always' monitoring neuromuscular function using clinical methods such as sustained head raise or hand grip.

Audible signals and alarms must be always activated and heard throughout the operating room. However, this does not seem to be consistent at TASH as only 17% (n=8) of the participants responded

to this scenario occurring as ‘always’ and 83% of the participants responded to this scenario occurring as ‘sometimes’.

Postoperative practices such as postoperative patient monitoring and accompanying while transferring patients by anesthesia professionals and handing them over to the post anesthetic care unit nurses seem to be very good as all study participants claimed to “always” perform them. Continuous pulse oximetry to monitor all postoperative patients could be considered as being applied to the majority of cases as 90% of all the participants claimed this scenario as ‘always’ happening. All patients are entitled to postoperative pain management. However, this wasn’t always the case at TASH as only 85% (n=39) of the participants responded to this scenario occurring as ‘sometimes’.

Discussion

WFSA-recommended anesthesia personnel for a level 3 hospital i.e. officers and specialists in anesthesia were available at TASH. Furthermore, according to the WFSA anesthesiologists should be trained and accredited with clinical and administrative autonomy in anesthesia practice. They also should train and accredit as well as direct and supervise non-medical anesthesia personnel. TASH, while under such a framework, still required an increased number of physician and non-physician anesthesia care providers. The number of anesthesiologists available was not adequate to provide full supervision and care for all anesthetic services carried out in the hospital. As a result, anesthesiology residents and anessthetists managed many patients without the supervision of an anesthesiologist. The implication of this was not only in terms of questionable safety of patients but also in the quality of the residency training process and lack of time for personal development from the anesthesiologists' side as well. The contemporary number of residents, 36 at TASH and ~30 at Saint Paul Millennium Medical College Hospital and Jimma University Hospital i.e. the other places where anesthesiology residency was being given in Ethiopia (personal communication) was a massive increase when compared to the numbers in 1990 and 1991 when only 8 anesthesiologists graduated from six east African nations, including Ethiopia, together. (Greene, 1991) The enrolment in anesthesiology at TASH over the past 3 years had been the highest ever since the department of anesthesiology was inaugurated. Possible reasons identified included the inclusion of anesthesiology attachment in undergraduate medical curriculum (especially at TASH), increased awareness of physicians and last but not least recognition of the field of anesthesiology by the ministry of health of Ethiopia as scarce but fundamental.

According to WFSA's standards, in terms of performed surgeries TASH could be categorized as a level 3 hospital. However, in terms of available equipment and monitors it did not qualify even as a level 2 hospital which was the scenario in the majority of LMICs (LeBrun DG et al., 2014).

Although modern anesthesia machines were available in all the operating rooms, none had a full set of basic airway management equipment. Whenever anesthesia professionals could not find the equipment their patient required in their room, they frequently would 'borrow' it from the other rooms leaving them deficient.

As a level 3 hospital, a full set of airway management equipment is expected to be available as at least one set each per operating room. Management of an unanticipated difficult airway would be difficult as

there isn't a stylet/bougie available in each operating room. Neither is a difficult airway trolley that everyone could access anytime under such circumstances. The presence of a video laryngoscope and flexible fiber optic bronchoscopes, regardless of their origins meant that anesthesia professionals had wider and safer options in managing patients with both anticipated and unanticipated airway difficulties. This practice is more than level 3 hospitals' standard but an appreciable fulfillment of equipment considering TASH is the biggest hospital in the country and receiving all sorts of patients deemed difficult by other hospitals.

If instruments and devices such as epidural needles and catheters, insulated needles and nerve stimulators for peripheral nerve block, central venous lines and arterial catheters with pressure transducers were available, it would not only improve patient care but also the quality of the anesthesiology residency training. The ability to effectively utilize these instruments is one of the fundamental requirements of being an anesthesiologist. Although the department of anesthesiology is trying its best to avail these, their reliable presence cannot be assured by depending on donations. And this was one of the limitations of the training considered by interviewed residents. The hospital has to find ways not only to make these available but also to make sure that they are in constant and continuous supply so that the residency teaching as well as patient safety is conducted in an effective manner. Getting extra funds to fulfill equipment requirements and sustained supplies smj-=t hould be the next step in order for TASH to provide competent and safe practice of anesthesia.

In terms of drugs, TASH could be more or less categorized as equivalent to a level 3 hospital's standard. Availability of many of the drugs required for safe anesthetic practice as recommended by the WFSA was one of the relative strengths of TASH. Unlike other LMICS (LeBrun DG et al., 2014) consistent supply of a range of IV anesthetics and sedatives and neuromuscular blocking drugs meant that providers were not relying on a ketamine based anesthesia as practiced by majority of resource poor setups. However, considering the advanced natures of surgeries being done and the increment of patients with comorbidities extensive work is expected on the hospital's side to make available modern IV anesthetics (such as etomidate), inhalational agents (such as sevoflurane), neuromuscular blocking drugs (such as atracurium and cisatracurium), vasopressors and inotropes (such as phenylephrine, ephedrine, noradrenaline), calcium channel and beta blockers (such as diltiazem, verapamil, esmolol). In addition, the presence of IV infusion pumps would greatly enhance resuscitation as well as the practice of total intravenous anesthesia (TIVA) which was rarely practiced.

According to WFSA, all patients must receive formal/proper preanesthetic evaluation by an anesthesia professional. The presence of a preanesthetic clinic in TASH was a step ahead in terms of quality of a setup, as traditional practices such as admitting patients to the hospital a day before surgery to undergo preanesthetic evaluation is no longer a routine practice in many parts of the world. (Anju Gupta & Gupta, 2010) However, TASH preanesthetic practice showed only some and not all of the patients getting this service as only 13% of anesthetists and anesthesiology residents responded 'always' to the occurrence of formal preanesthetic evaluation of a patient by an anesthesia professional. This might stem from the fact that the numbers of anesthesia professional required to do the preanesthetic evaluation i.e. anesthesiology and anesthesiology attaching surgical residents was not proportional to the numbers of patients requiring the service. In addition, anesthetists not being involved in performing a formal preanesthetic evaluation of a patient may be another reason. Adoption of the WHO surgical safety check list by the hospital was one of its strengths. However, work has to be done in using this check list routinely. In addition, adoption of pre anesthetic check lists for verification of patient safety, equipment and drug availability is a recommended standard by WFSA. However there was not such a practice at TASH.

According to the WFSA, the first and most important component of peri-anesthetic care is the continuous presence of a vigilant anesthesia professional during anesthesia which was the case at TASH. Practices of intraoperative monitoring of oxygenation, airway and ventilation, heart rate and rhythm, blood pressure, and depth of anesthesia were all good and consistent despite the resources limitations. Practice regarding intraoperative temperature and neuromuscular function monitoring was poor as thermometers/thermometer probes and nerve stimulators were unavailable to perform such monitoring. Anesthesia professionals were consistently applying clinical methods to monitor these although such practices are subjective and their reliability is questionable.

Post anesthesia care service was overall good as the entire anesthesia professionals accompanied and monitored their patients when they were being transferred to the post anesthesia recovery facilities and followed a verbal hand over protocol, and there was consistent monitoring with pulse oximeters. However, postoperative pain management was not consistent and there were patients whose pains were not addressed. All patients are entitled to an appropriate effort for pain relief in the post anesthesia care facility. TASH, more or less, fulfilled WFSA's 'highly recommended' and/or 'recommended' standards in intraoperative monitoring (of oxygenation, airway and ventilation, heart rate and rhythm, blood pressure, and depth of anesthesia) and post anesthesia care.

See Tables 8 and 9 below for WFSA's recommendations on perioperative care and their execution at TASH.

Table 8 Pattern of Pre- and Post-anesthetic Care at TASH

Table 8 WFSA-Recommendations for Pre- and Post-anesthetic Care – Availability and Execution at TASH

Care	Standard*			
	Highly Recommended		**Recommended**	
Preanesthetic care				
	Formal preanesthetic evaluation of a patient by an anesthesia professional.	**13%** **n=6**	Adoption of a protocol or a check list for verification of safety and/or availability of the anesthesia system, equipment, drugs and patients.	**Unavailable**
	Anesthesia professional must ensure all the necessary equipment is present and functional	**n=82%**		
	WHO Safe Surgery Check List	**Available**		
Post anesthesia care				
Facilities and personnel	Patients must be cared for and monitored by anesthesia professional until recovery and while being transferred to the post anesthesia recovery facility.	**100%** **n=46**		
	A 'hand over' protocol should be followed when patients are transferred to the post anesthesia recovery facility.	**95%** **n=44**		
Monitoring	Patients' state of nervous system, vital signs and medical condition should be monitored clinically until they are awake and stable. Continuous monitoring with a pulse oximeter until awake and stable.	**100%** **n=46**	Continuous quantitative monitoring similar to intraoperative monitoring standards (NIBP, ECG, Capnography, Temperature etc.)	**Available**
Pain relief	All patients are entitled to appropriate efforts to prevent and alleviate postoperative pain; initial responsibilities assumed by the involved anesthesia professional.	**15%** **n=7**		

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital
* There were no 'Suggested standard(s)' for this pre- and post- anesthetic care; therefore the column was omitted on this table.

Table 9 Pattern of Intraoperative Monitoring at TASH

Table 9 WFSA-Recommendations for Intraoperative Monitoring- Availability and Execution at TASH

Monitoring	Standard*			
	Highly Recommended		Recommended	
Oxygenation	Supplemental oxygen for all patients undergoing general anesthesia.	**100% n=46**	Monitoring of inspired concentration of oxygen with an instrument fitted with low oxygen concentration alarm.	**Available**
	Verification of the integrity of oxygen supply by an anesthesia professional.	**100% n=46**	Systems with interlocks to prevent misconnection of gas sources.	**Available**
	Continuous monitoring of tissue oxygenation by a pulse oximeter	**100% n=46**		
[1]Airway and ventilation	Continuous monitoring of airway and ventilation at least by observation and auscultation or reservoir bag excursion	**95% n=44**	Continuous monitoring with precordial, pretracheal, or esophageal stethoscope	**5% n=2**
Heart rate and rhythm	Continuous monitoring with palpation or auscultation Continuous monitoring with pulse oximetry	**15% n=7**	Continuous monitoring with electrocardiography	**100% n=46**
[2]Blood pressure	Blood pressure monitoring at least every 5 minutes	**100% n=46**	Automated non-invasive blood pressure monitoring.	**100% n=46**
Temperature	A thermometer should be available and used at frequent intervals if indicated.	**Unavailable**	Continual measurement of temperature (when indicated). Continuous electronic temperature measurement.	
Neuromuscular function			Use of a peripheral nerve stimulator to monitor neuromuscular function if neuromuscular blocking drugs are given	**Unavailable**
[3]Depth of anesthesia	Regular assessment by clinical observation	**100% n=46**		
Audible signals and alarms	Activated and loud enough to be heard throughout the operating room	**17% n=8**		

Abbreviations: WFSA, World Federation of Societies of Anesthesiologists; TASH, Tikur Anbessa Specialized Hospital
* Column for Suggested standards is not shown on this table; variables with suggested standards are numbered 1, 2, 3. Suggested standard(s) for 1 Airway and ventilation are the continuous measurement of the inspiratory and/or expired gas volumes, and of the concentration of volatile agents and 2 Blood pressure is continuous measurement and display of arterial pressure and 3 Depth of anesthesia monitoring is the continuous measurement of inspired and expired concentrations of anesthetic gases and volatile agents

Limitations and Strengths of the Study

Limitations

The study was done on a single institution and as such does not represent the safety and pattern of anesthetic practice elsewhere in the country. The study also did not include figures that could have showed the anesthetic and surgical volume of the hospital because of poor documentation and ease of access issues.

Strengths

The study is the first of its kind. It can be used as a baseline study for further quantitate study in the future. The institution can also make adjustments to improve anesthetic care of the hospital based on the findings of this research.

Conclusion

From the findings of the study, TASH can be considered as a tertiary care (level 3) hospital running on a level 2 equivalent hospital's resources. The majority of perioperative anesthetic care practices with some exceptions fulfilled the 'Highly recommended' standards of the WFSA, which was equivalent to mandatory standards (level 1/basic). It had significant limitations of resource with respect to anesthesia equipment and monitors. There was a promising rise in the number of anesthesiology residents which could be a beginning for the resolution of the shortage issue in the anesthesia work force capacity in the hospital as well as the country.

Recommendations

Based on the results of the study the following recommendations can be made:

- Increasing the number of anesthesia care providers by recruiting more physicians to join anesthesiology and hiring more anesthetists should be considered as it would solve problems stemming from shortage of work force so that there will be supervision of anesthetic care by anesthesiologists, preanesthetic evaluation of all patients and increased quality of anesthesiology residency training.

- Every effort should be made to meet the 'highly recommended', 'recommended' and 'suggested' standards of the WFSA as a tertiary (level 3) hospital.

- Anesthesia equipment, monitors and drugs not available for a level 3 hospital should be made not only available but also their constant supply should be ensured.

- Central venous and arterial catheters with pressure transducers, epidural needles with catheters, peripheral nerve block needles and stimulators should be made not only available but also their constant supply should be ensured in order to increase safety of patients as well as the quality of anesthesiology residency training.

- Adoption of pre anesthesia check lists for verification functionality of equipment and safety of patients should be highly considered in order to make patient safety systematic.

- Airway and ventilation monitoring should be supplemented by end tidal capnography.

- Neuromuscular function monitoring should be peripheral nerve stimulator guided.

- A means of measuring temperature and depth of anesthesia of patients should be made available.

- Post-operative analgesia for all patients should be provided to all patients in the post anesthesia care facilities.

- Establishment of post anesthesia care facility for post-operative obstetric patients should be considered.

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Annex

Annex 1 – Checklist for Equipment

No.	Equipment (Capital outlay)	Yes	No	Comment
	Level 1			
1.	Adult and pediatric self-inflating breathing bags with masks			
2.	Foot-powered suction			
3.	Stethoscope, sphygmomanometer, thermometer			
4.	Pulse oximeter			
5.	Oxygen concentrator or tank oxygen and a draw-over vaporizer with hoses			
6.	Laryngoscopes, bougies			
	Level 2 Same as Level 1 with these additions			
7.	Complete anesthesia, resuscitation and airway management systems including:			
8.	Reliable oxygen sources			
9.	Vaporizer(s)			
10.	Hoses and valves			
11.	Bellows or bag to inflate lungs			
12.	Face masks (sizes 00–5)			
13.	Work surface and storage			
14.	Pediatric anesthesia system			
15.	Oxygen supply failure alarm; oxygen			
16.	Analyzer			
17.	Adult and pediatric resuscitator sets			
18.	Pulse oximeter, spare probes, adult and pediatric			
19.	Capnograph			
20.	Defibrillator (one per O.R. suite / ICU)			
21.	ECG (electrocardiograph) monitor			
22.	Laryngoscope, Macintosh blades 1-3(4)			
23.	Oxygen concentrator[s] [cylinder]			
24.	Foot or electric suction			
25.	IV pressure infusor bag			
26.	Adult and pediatric resuscitator sets			
27.	Magill forceps (adult and child),			
28.	intubation stylet and/or bougie			
29.	Spinal needles 25G			
30.	Nerve stimulator			
31.	Automatic non-invasive blood pressure Monitor			

Annex 1 – Checklist for Equipment (continued)

No.	Equipment (Capital outlay)	Yes	No	Comment
	Level 3 Same as Level 2 with these additions (per operating room or per ICU bed, except where stated):			
1.	ECG (electrocardiograph) monitor			
2.	Anesthesia ventilator, reliable electric power source with manual override			
3.	Infusion pumps (2 per bed)			
4.	Pressure bag for IV infusion			
5.	Electric or pneumatic suction			
6.	Oxygen analyzer			
7.	Thermometer [temperature probe			
8.	Electric warming blanket			
9.	Electric overhead heater			
10.	Infant incubator			
11.	Laryngeal mask airways sizes 2, 3, 4 (3 sets per O.R)			
12.	Intubating bougies, adult and child (1 set per O.R)			
13.	Anesthetic agent (gas and vapour) analyser			
14.	Depth of anesthesia monitors			

Annex 1 – Checklist for Equipment (continued)

No.	Equipment (Disposable)	Yes	No	Comment
	Level 1			
1.	Examination gloves			
2.	IV infusion/drug injection equipment			
3.	Suction catheters size 16 FG			
4.	Airway support equipment, including airways and tracheal tubes			
5.	Oral and nasal airways			
	Level 2 Same as Level 1 with these additions:			
6.	ECG electrodes			
7.	IV equipment (minimum fluids: normal saline, Ringer's lactate and dextrose 5%)			
8.	Pediatric giving sets			
9.	Suction catheters size 16 FG			
10.	Sterile gloves sizes 6–8			
11.	Nasogastric tubes sizes 10–16 FG			
12.	Oral airways sizes 000–4			
13.	Tracheal tubes sizes 3–8.5 mm			
14.	Spinal needles sizes 22 G and 25G			
15.	Batteries size C			
	Level 3 Same as Level 2 with these additions:			
16.	Ventilator circuits			
17.	Yankauer suckers			
18.	Giving sets for IV infusion pumps			
19.	Disposables for suction machines			
20.	Disposables for capnography, oxygen analyzer, in accordance with manufacturers' specifications:			
21.	Sampling lines			
22.	Water traps			
23.	Connectors			
24.	Filters – Fuel cells			

Annex 2 – Checklist for Drugs

No.	Drug	Yes	No	Comment
	Level 1			
1.	Ketamine 50 mg/ml injection			
2.	Lidocaine 1% or 2%			
3.	Diazepam 5 mg/ml injection, 2 ml or			
4.	midazolam 1 mg/ml injection, 5 ml			
5.	Pethidine 50 mg/ml injection, 2 ml			
6.	Morphine 10 mg/ml, 1 ml			
7.	Epinephrine (Adrenaline) 1 mg			
8.	Atropine 0.6 mg/ml			
9.	Appropriate inhalation anesthetic if vaporizer available			
	Level 2 Same as Level 1 with these additions:			
10.	Thiopental 500 mg/1 g powder or propofol.			
11.	Suxamethonium bromide 500 mg powder			
12.	Pancuronium			
13.	Neostigmine 2.5 mg injection			
14.	Ether, halothane or other inhalation anesthetics			
15.	Lidocaine 5% heavy spinal solution, 2 ml			
16.	Bupivacaine 0.5% heavy or plain, 4 ml			
17.	Hydralazine 20 mg injection			
18.	Furosemide 20 mg injection			
19.	Dextrose 50% 20 ml injection			
20.	Aminophylline 250 mg injection			
21.	Ephedrine 30/50 mg ampoules			
22.	Hydrocortisone			
23.	Nitrous oxide			
	Level 3 Same as Level 2 with these additions:			
24.	Propofol			
25.	Nitrous oxide			
26.	Various modern neuromuscular blocking agents			
27.	Various modern inhalation anesthetics			
28.	Various inotropic agents			
29.	Various intravenous antiarrhythmic agents			
30.	Nitroglycerine for infusion			
31.	Calcium chloride 10% 10 im injection			
32.	Potassium chloride 20% 10 ml injection for infusion			

Annex 3 – Questionnaire

Questionnaire

This questionnaire is prepared to assess the pattern and safety of anesthetic practice in Tikur Anbessa Specialized Hospital as part of the dissertation thesis done by Robel Seifu, MD (Final year anesthesiology resident). The terms of agreement have been explained to me and by filling this questionnaire I agree to participate in the study.

Study ID. No_____

1. Demographic data

a) Age (years): _____

b) Sex: (A) Male (B) Female

c) Qualification

(1) Anesthetist (please specify level of training)

(a) Nurse anesthetist

(b) BSc. in Anesthesia

(c) MSc. In Anesthesia

(d) Other: _____

(2) Anesthesiology Resident (please specify year of residency)

(i) Second year resident

(ii) Third year resident

2. Assessment of Pre-anesthetic Care

2.1. How often do your patients get an **appropriate** pre-anesthetic evaluation by an anesthesia professional prior to administration of anesthesia? (**Appropriate – proper documentation of the history, physical examination and relevant investigation findings of a patient and the formulated anesthetic plan.)**

A. Always

B. Sometimes

C. Never

2.2. Does your institution have a standard format or check list on which patient's pre-anesthetic evaluation information gets recorded?

A. Yes

B. No

C. I don't know

2.3. How often do you ensure that all the necessary equipment is present and functional prior to administration of anesthesia?

A. Always

B. Sometimes

C. Never

2.4. Does your institution have a standard check list or protocol to ensure that all the necessary equipment is present and functional prior to initiation of anesthetic care?

A. Yes

B. No

C. I don't know

3. Assessment of Intraoperative monitoring

3.1. How often do your patients receive supplemental oxygen when undergoing general anesthesia?

A. Always
B. Sometimes
C. Never

3.2. How often do you check the integrity of the oxygen supply?

A. Always
B. Sometimes
C. Never

3.3. Which of the following method(s) and/or device(s) do you apply to monitor the tissue oxygenation of a patient?

A. Visual assessment
B. Continuous pulse oximetry
C. Arterial blood gas analysis
D. Other (specify) _____

3.4. How often do you use continuous pulse oximetry to monitor tissue oxygenation of patients?

A. Always
B. Sometimes
C. Never

3.5. Which of the following method(s) and/or device(s) do you apply to monitor the adequacy of the airway and ventilation of patients?

A. Continuous observation and auscultation of the chest.
B. Continuous precordial, pre-tracheal or esophageal stethoscopy.
C. Continuous capnography.
D. Continuous measurement of the inspiratory and/or expiratory gas volumes and/or concentrations.
E. Other (specify) _____

3.6. Which of the following method(s) and/or device(s) do you apply to monitor the heart rate and rhythm of patients?

A. Continuous palpation and auscultation.
B. Continuous monitoring and display of the heart rate with a pulse oximeter.
C. Continuous electrocardiographic monitoring.
D. Other (specify) _____

3.7. Which of the following method(s) and/or device(s) do you apply to monitor the blood pressure of patients?

A. Manual blood pressure measurement, at least every five minutes.
B. Automated noninvasive blood pressure measurement.
C. Invasive arterial blood pressure measurement.
D. Other (specify) _____

3.8. Which of the following method(s) and/or device(s) do you apply to monitor the temperature of your patients?

A. Comparing patients' temperature with one's own skin temperature.
B. Intermittent temperature measurement by a portable thermometer.
C. Continuous electronic temperature measurement.
D. Other (specify) _____

3.9. Which of the following method(s) and/or device(s) do you apply to monitor the neuromuscular function of patients when neuromuscular blocking drugs are given intraoperatively?
   A. Peripheral nerve stimulator guided neuromuscular monitoring.
   B. Clinical monitoring parameters (such as sustained head lift, hand grip etc.)
   C. Other (specify) _____

3.10. Which of the following method(s) and/or device(s) do you apply to monitor the depth of anesthesia in patients?
   A. Regular clinical observations.
   B. Continuous end tidal anesthetic gas concentration measurement.
   C. Other (specify) _____

3.11. How often are audible signals and alarms activated and loud enough to be heard throughout the operating room?
   A. Always
   B. Sometimes
   C. Never

4. Assessment of Post anesthesia care

4.1. How often are patients accompanied by an anesthesia care professional when being transported to the post anesthesia recovery facility?
   A. Always
   B. Sometimes
   C. Never

4.2. Does your institution have a **"handover"** protocol when transferring responsibility of care for patients to another anesthesia care or other professionals (such as nurses or physicians working in the post anesthesia recovery facility)?
   A. Yes
   B. No
   C. I don't know

4.3. How often is continuous pulse oximetry applied to monitor post-operative patients in the post anesthesia recovery facility?
   A. Always
   B. Sometimes
   C. Never

4.4. How often is post-operative pain treated or addressed in the post anesthesia recovery facility?
   A. Always
   B. Sometimes
   C. Never