



Quality Improvement Study



Assessment of pre-anesthesia machine check and airway equipment preparedness: A cross-sectional study

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ABSTRACT

Background: Anesthesia Equipment malfunction is one of the most common factors contributing to intraoperative surgical patient morbidity and mortality. It is impossible to give anesthesia without proper anesthesia machine checks and airway equipment preparation. Therefore, all anesthesia professionals should make sure that the anesthetic machine and equipment are working correctly.

Method: An institutional-based prospective observational study was conducted at the University Comprehensive Specialized Hospital, Operation rooms, from April 10, 2020 to May 10, 2020. About 90 anesthetists were working regularly in the operation theater both emergency and elective patients. Those include; 26 MSc holders, 17 MSc students, 7 BSc anesthetists, and 40 graduating BSc students. These descriptive data were presented with frequency, percentage, and table.

Result: The overall compliance rate was 87%. Whereas; 12.46% of clinicians have not met the standard. Out of standards that were not performed, 25.81% were not available from the setup.

Conclusion: The result shows that there was poor compliance with anesthesia machine check and equipment preparation before anesthesia in the operation theater according.

1. Background

Even though the quality of anesthesia service has increased in recent years, errors are not avoidable and take the majority of anesthesia-related patient complications [1,2]. Thus Anesthesia Equipment malfunction is one of the most common factors contributing to intra-operative surgical patient morbidity and mortality [3]. It is impossible to give anesthesia without proper anesthesia machine checks and airway equipment preparation. Therefore, all anesthesia professionals should make sure that the anesthetic machine and equipment are working correctly [4]. Furthermore, Every anesthetist has a responsibility to know and check the function of the anesthetic equipment and to prepare before use for patient safety [5]. Despite there being a variety of anesthesia machines with different modes and designs, there are common parameters on how to check before use [6]. In addition,

there are also recommended anticipated and unanticipated difficult airway management equipment [7–13]. Airway complications are among the most common problems during the conduct of anesthesia. Effective airway management depends on the immediate availability of a range of different airway aid equipment. Many difficult airways are not predictable so a dedicated difficult airway container with labeling is mandatory. The selection of airway equipment needs to be prioritized to maintain oxygenation and ventilation of the patient [14,15].

The difficult airway can result in damage to the teeth, airway trauma, unnecessary surgical airway, brain injury, and cardiopulmonary arrest [16,17]. Therefore, according to the national audit project (NAP4) report the most contributing factors for poor outcomes regarding airway management were deficiencies in judgment and inadequate equipment preparedness. As evidence recommends, machine checks and airway equipment be performed on daily basis [10,14,18–21]. Furthermore,

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The properly labeled equipment container provides the right equipment, in the right amount, in the right place, at the right time [22,23].

A study done in Denmark showed that the incidence of unanticipated difficult intubation was 1.87%. On the other evidence, the incidence of difficult facemask ventilation was 0.5–1.5% and failed laryngeal mask insertion has been reported as above 1% and the failed intubation occurs in 0.01% [24].

In the University of Gondar comprehensive specialized hospital operation theatre, anesthesia machines are checked in detail daily specifically in the morning and roughly before every surgical procedure.

Similarly, airway equipment is also checked and prepared. However, it is still not known whether the quality of check and preparedness is in line with the standard. Due to this, we aimed to assess machine checks and airway equipment preparedness before anesthesia.

2. Materials and methods

2.1. Design, area, and period

An institutional-based prospective observational study was conducted at the University of Gondar comprehensive specialized hospital, Operation rooms, from April 10, 2020 to May 10, 2020. This study is already registered at www.researchregistry.com and its unique identifying number is: [researchregistry7532](https://www.researchregistry.com/record/2021/04/29/103775). This paper has been report with STROCSS 2021 criteria [37].

The University of Gondar comprehensive specialized hospital is located 738 Km far from Addis Ababa to Northwest Ethiopia and 173 km from Bahir Dar (capital city of the Amhara region) to the North-East direction. This comprehensive specialized hospital undergoes a variety of operations. Currently, this university also included three other health centers. Each health center has one operation theater for cesarean section. Therefore, generally, there were ten [10] operation theatres during this study time. Four general surgery rooms including pediatrics, one orthopedic, two fistulae, two cesarean sections, and one ophthalmic theatre.

There were 90 anesthetists were included. Among them 26 were Msc holders, 17 MSc students, 7 BSc anesthetists, and 40 graduating BSc students, who were working regularly in the operation theater of both emergency and elective patients. The machines are checked regularly on the morning of each day and roughly before the induction of every surgical case. Similarly, Airway equipment is also prepared before. Machines check and equipment preparation are done by BSc and MSc students who are supervised by the tutors. Those students have checklists on how to check the machine prepared from different pieces of evidence [19,25,26] in addition airway equipment is prepared based on DAS algorithms. The main aim of the checklist was to teach students about the safety of the machine and equipment. The checklists are directly converted into question forms involving yes and no.

2.2. Data processing and analysis procedures

After completion of data collection, the data were entered in SPSS version 21 for analysis. Table was used to report the descriptive statistics.

3. Result

A total of 202 checking and preparing events were observed from April 10, 2020 to May 10, 2020 in the operation theatre before starting anesthesia and surgery.

The overall compliance rate was 87%. Whereas, 12.46% have not met the standard. Out of standards that were not performed, 25.81% were not available from the setup.

Electrical supply to machine, checking cylinder pressure, bobbins move freely, ant hypoxic device, rotameter leak, breathing circuit pressure leak test, pulse oximetry, NIBP functionality, three different

sizes laryngeal mask airway and availability of different laryngoscope had above 95% compliance with the standards. As the table illustrates clearly, oxygen failure alarm, vaporizer check for correctly seated and filled and check for leak, breathing circuit check for (configuration and connection), soda-lime inspected, the functionality of APL valve and unidirectional valve were checked above 90% and below 95% before induction of anesthesia. In addition, Pressure regulator setting, oxygen flush checked, breathing circuit gas delivery through a face mask, ventilator function checked and gases delivery through a face mask, Suction apparatus (functional) and ETT with introducer bougie (1 set per O.R) and stylet were checked between 80 and 90%. Capnography check and functionality, checking the availability of self-inflating bag and airway (oral and nasal) were had 9.95, 64.37%, and 69.31% compliance respectively (Table 1) (see Table 2).

4. Discussion

Despite the increasing number and quality of anesthesia providers and anesthesia equipment, human errors are not avoidable but can be reduced by using checklists to check every important piece of equipment and anesthesia machine checking lists and steps [1]. Therefore, it is crucial to check the anesthesia machine components carefully before induction of anesthesia. So a simple pre-use checklist for anesthetic machines is recommended [27]. Furthermore, current modern anesthesia machines have alarms of abnormality if set properly and checked based on standards that can reduce human-related errors. A study done in Norway conclude that Human errors of misuse or insufficient anesthesia machine check were the most common cause of anesthesia-related complications [3]. Therefore, proper use of anesthesia machine checking and checklist are mandatory for better outcomes of surgical patients. Even though, modern anesthesia machines incorporated automated checkout, additional manual checkups are required to ensure a proper

Table 1

Anesthesia machine checklist at university of Gondar comprehensive specialized hospital Operation Theatre, (202).

Variables	yes	Not	Percent (%)
1. Is the electrical supply to the machine checked?	192	10	95
2. Is the oxygen supply (cylinder) to the machine is checked with			
2a. Cylinder pressure	197	5	97
2b. Pressure regulators setting	174	28	86
2 c. Oxygen failure alarm	190	12	94
3. Rotameter checked with			
3a. Bobbins move freely	191	11	95.55
3b. Anti-hypoxic device checked	198	4	98.02
3 c. Oxygen flush checked	178	24	88.12
4 c. Leak checked	200	2	99.01
4. Vaporizer checked for			
4 a. Correctly seated	186	16	92.08
4 b. Filled and checked for leak	185	17	91.58
5. is Breathing Circuit checked for			
5 a. Configuration and connection	190	12	94.06
5 b. Soda-lime inspected	183	19	90.59
5 c. Pressure leak test performed	194	8	96.04
5 d. Function of APL valve and unidirectional valve	190	12	94.06
5 e. Gases delivery through the face mask	179	23	88.61
6. Is Ventilator checked for			
6 a. Ventilator tubing configuration	170	32	84.16
6 b. Appropriate control setting			
6 c. Ventilator function checked and gases delivery through face mask	175	27	86.63
7. Scavenging Is connected and functioning checked	160	42	79.21
8. Alternative means of ventilation	130	72	64.37
Checked self-inflating bag is available			
9. Monitoring checked			
9 a. Pulse oximeter checked	200	2	99.01
9 b. Capnography checked and functional	20	182	9.90
9 c. NIBP measurement functional	195	7	96.53
Unanticipated difficult airway preparation			

Table 2

Airway equipment preparation at University of Gondar comprehensive specialized hospital Operation Theatre, (202).

1	Different size ETT	185	17	91.58
2	Laryngeal mask (3 sets per O.R)	194	8	96.04
3	Different size laryngoscope blade	192	10	95.05
4	Suction apparatus (functional)	167	35	82.67
5	ETT introducer bougie (1 set per O.R) and stylet	166	36	82.18
6	Airways (oral or nasal)	140	62	69.31

checkout [28]. Despite an uneventful automated machine checkout has been documented, there were previous reports of machine failures and mostly related to the APL valve [29]. A study in Australia on an analysis of 2000 incidents reported that Failure to check the anesthesia machine was a contributing factor in 14% of all incidents and failure to properly assess patients preoperatively contributed to the occurrence of a further 6% or, more than 2000 incidents as reported by the Australian Incident Monitoring study [30].

This result showed that anesthesia machine check and equipment preparation is more or less similar to the clinical audit done by Samuel Debasu and his colleagues at Debre Birhan referral hospital but, the Debre Birhan study was conducted among 61 machine checks. Whereas, our study was conducted among 202 checking events [20]. However, this study is under practiced when compared with most standards [18, 31,32]. The result of the current study also shows that equipment checking and preparation is underperformed when compared with a study done in Saudi Arabia. The Saudi Arabia study was different from our study in terms of study period which took greater than ten months in contrast our study underwent within one month [19]. In our study, the functionality of the APL valve was checked according to the standard by 94% of practitioners. Anesthesia machine leaks may lead to hypoxic fresh gas mixtures, ineffective ventilation, or the lack of volatile anesthetic delivery, all potentially contributing to patient mortality and morbidity [33].

Different studies recommend the need for training for anesthetists to maximize their skills and knowledge on anesthesia machine checks. A study done in Canada showed that an experiential training session on pre-anesthesia checkout allowed junior practitioners to achieve skills superior to those of senior colleagues [34].

Even though Capnography is one of the minimum standards of anesthesia monitoring and it comes with every integrated monitoring, it was not available in most operation theaters in our study area. Furthermore, the result of this study showed low practical usage of capnography as compared with another survey study conducted in England on tracheal intubation among emergency departments in 198 incidents. Moreover, this survey found that 74% of the respondents use capnography [35]. The reason might be inappropriate use and negligence of safety care between anesthesia providers. However, it is important to confirm the recommended position of the endotracheal tube and achieved most safely by the use of a capnograph which measures the expired carbon dioxide levels. Ideally, no anesthetic should be started without checking capnograph functionality [27].

A cross-sectional study done in Israel with a simulation-based scenario to measure the performance of anesthesiology residents on pre-anesthesia machine checkout showed that the majority of students (examinees) failed to correctly check 70% of the items between cases and also failed to correctly check at least 70% of the items on the anesthesia machine checkout list before the first-morning case. Although all examinees recognized a malfunctioning valve and inadequate oxygen cylinder pressure, some of the examinees failed to open the O2 cylinder and did not disconnect the anesthesia machine from the central oxygen supply [36]. Whereas, our study result showed a higher compliance rate (87%) of pre-anesthesia checkout compared with the above study (which was a 30% compliance rate). The possible justification for this variation might be due to the difference in the study area

and the low sample size. Accordingly, the Israel study was conducted on 119 resident anesthesiology over a four-year period.

Authors' contribution

All the authors contributed to conception, design, analysis of data, revising article, gave final approval to be published, and agree to be responsible for this work.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical clearance was obtained from university of Gondar comprehensive and specialized hospital ethical review committee.

Disclosure

All authors declared that they have no computing interest.

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Limitation

This study didn't show factors affecting the low compliance of anesthesia machine check and equipment preparation. This study used a small sample size.

Conclusion and recommendation

The result shows that there was poor compliance of anesthesia machine check and equipment preparation before anesthesia induction in the operation theater according to the standards. Therefore, we suggest that every responsible anesthesia provider should check and prepare before any kind of surgical case at any time.

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Registration of research studies

1. Name of the registry: Research [registry.com](https://www.researchregistry.com).
2. Unique Identifying number or registration ID: researchregistry7532.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://www.researchregistry.com/browse-the-registry#home/>

Guarantor

The guarantor of this study are; Habtu Adane, Desalegn Muche, Yophtahe Woldegerima, Wubie Birlie, Misganaw Mengie, and Shimelis Seid.

Declaration of competing interest

The authors declare that there is no conflict of interest between the Authors.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.103775>.

Acronyms and abbreviations

ASA	American Society of Anesthesiologist
DAS	Difficult Airway Society
I-LMA	Intubating Laryngeal Mask Airway
SASA	South African Society of Anesthesiologist

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