Review Article

Pre-anesthesia checkup(PAC) - A training programme for checking anaesthesia machine and testing anesthesia breathing systems–routinely used

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Abstract

Every hospital should have a protocol and methods to have PAC. A workshop/training programme, conducted for Anesthesia postgraduate students and working technicians. During workshop comprehensive lecture on working and designs of anesthesia machines with practical demo was taken. A hands on training was also given. At the end of workshop, the importance and effectiveness was analysed by feedback questionnaire to all participants and conclusion drawn. **Conclusion:** All 10 participants in the workshop had satisfactory understating and training; as analysed by feedback questionnaire. The teaching hospitals should have their own training programme. Periodically conducted and updated PAC should be practiced every day, which gives confidence in handling cases and machines.

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INTRODUCTION

Proper checking of any system, equipment or machine is a prerequisite of it's proper and optimal use[1]. A utility machine like that of Anesthesia machine - advanced anesthesia work station; which performs multiple functions while delivering Anesthesia, needs meticulous and well planned preanesthesia check out system - PAC, to avoid mishaps[2] and reduce morbidity and mortality[3,4,5,6]. An understanding of Anesthesia machine has to be from history through various stages of development. Sushruta Samhita "400 BC mention many forms of Anesthesia using wine and herbals. There were many discoveries and revelations during 8th to 18th centuries. The real practice of Anesthesia as science started from the day of Ether Anesthesia 16th October 1846. The first Anesthesia machine was introduced to clinical practice by Henry Edmund Gaskin Boyle – 1917, since then many working parts were added namely: Vapourizing bottles, CO_2 absorber, rotameters and safety devices. First Boyles apparatus arrived in Calcutta 1935. Indian O2 co. (IOL) took over the import and manufacture of Boyles. 21st century is era of digital technology. Anesthesia machines /monitoring systems have gone digital. The Anesthesiologist /Anesthesia technician/, Anesthesia care provider is ultimately responsible for proper functioning of equipment for safe Anesthesia. So adequate familiarity and relevant application makes PAC mandatory and Recordable[7,8,9]. Newer Anesthesia machines developed by various Multinational companies; have evolved in to complex Electrical, Mechanical and Pneumatic multicomponent work stations. Many functions of these machines are controlled by Automated checkout. An automated checkout again needs to be monitored and recorded manually as per the documentation of PAC for safe anesthesia[10].

PROJECT ACTIVITY

For this Five(5) Anesthesia postgraduate students and Five5) Anesthesia technicians who are responsible for

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checkup and maintenance of equipments are selected. A comprehensive lecture is given on the subject of Design and functioning of Anesthesia machine and supportive breathing systems.

A) The Basic Functions of the Machine

1. To deliver oxygen (O_2), Nitrous Oxide (N_2O) as desired at safe pressure.
2. To control the flow and composition of the gases easily.
3. To permit the addition of precise concentration of volatile anesthetics.
4. To have ventilator support system, monitoring system incorporated.

B) The Basic Designing of Machine

The main designing of the machine is done with aim of providing the above functions with many additional features as per the company within the guidelines of safety features of world Anesthesia bodies. A Schematic Diagram of Anesthesia Machine.

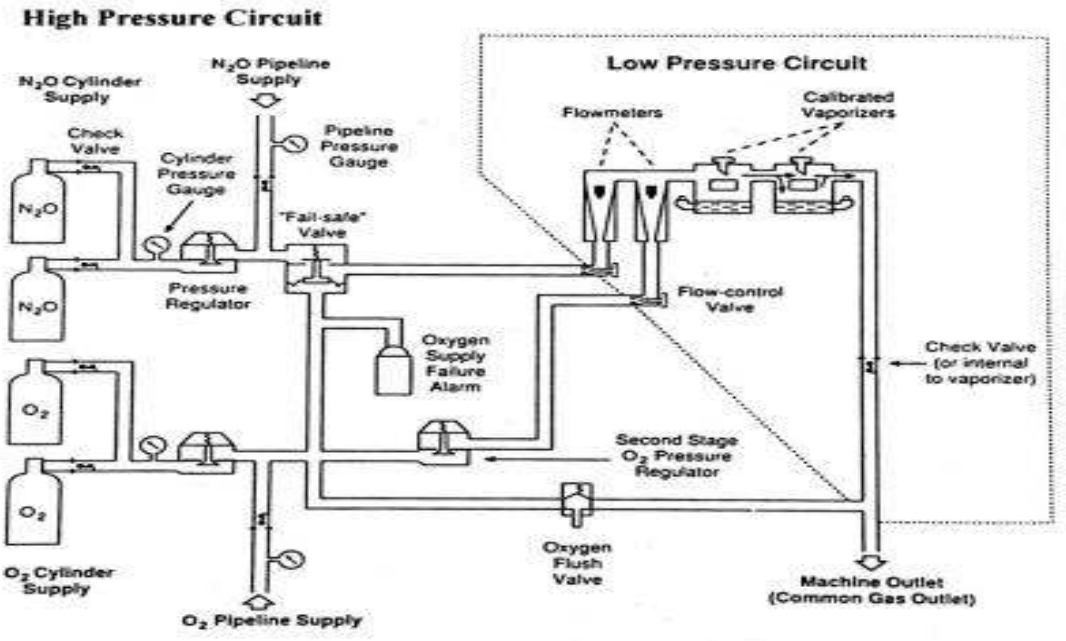

Figure 1: High pr.sys Inter pr.sys Low pr.sys

Figure 2: Anaethsesia workstation

(C) Anesthesia Breathing System

Is defined as an Assembly of components that connect patient's airway to machine outlet. Consist of : Connectors, tubes-hoses, reservoir, flow directing valves and CO_2 absorber. The two important Breathing System that are in routine use, that need to be understood well and need to be checked before each Anesthesia are.

1. Bain's circuit (Modified Mapleson D)
2. Circle System with CO_2 absorber.

Bain Circuit: is co-axial circuit. Inner black or green common tube carries fresh gas flow to patient end. Outer transparent 22 mm corrugated tube - carry expired Gas to Exp. valve near machine end. Reservoir bag - Near machine end **Circle System** has-Two limbs: Inspiratory– unidirectional valve-Fresh gas tubing; Expiratory - unidirectional valve - CO_2 absorber outlet. Expired gas from patient - to CO_2 canister

Reservoir Bag - Ventilator Selector Switch.

Design and description on an average Modern Anesthesia Machines have two components. I) Electrical II) Pneumatic

I) Electrical

1. Master switch - Main switch or ON-OFF switch - To be switched on and kept on standby position to keep the system powered.
2. Indicator Light for Mains power and alarm system for failure.
3. Battery backup power - check battery status.

There will be additional features which need to be checked as per Manual.

II) Pneumatic Components: powered by pressure, can be devided in to 3 parts.

A) High pressure system

Receives Gases from central pipe line or Gas cylinders at high pressure and regulates and measures pressures. Pressure regulators and pressure gauges are attached to the pipe lines or cylinders connected by various controls and connectors with safety system like, PISS (Pin Index Safety System) Colour Codes - DISS (Diameter Index Safety System)

B) Intermediate Pressure System

This is the 2nd stages pressure reduction which helps in protecting delicate machine parts and allows for steady and controlled flow. The components in this system include

1. Master Switch: Pneumatic or Electronic.
2. Pipe Line Inlet connections guarded by unidirectional check valve and filter.
3. Pipeline pressure gauges: Found on the panel of machine (usually colour coded). The pipe line pressure Indicators should always be checked to show a constant pressure between 50-55 PSIG (350-380 KPa). When not in use the cylinder valve should always be closed.
4. Oxygen flush or emergency O2 bypass receives O_2 directly from inlet with high unmetered flow and delivery directly to common Gas outlet. (Bypassing low pressure system i.e. flow meters and vapourizers). It is independent of master switch. Attains - Maximum flow of 35-75 L/mt.
5. 2nd stage pressure regulator - Just upstream of flow meter to reduce pressure of O_2 to14 PSI (95 KPa) and N_2O to 26 PSI (177 KPa). The flow will remain more constant.
6. Flow control valve - at the base of flow meter (Pin valve or Needle valve) for fine control of flow - creating low pressure system downstream.

(C) Low Pressure System

This begins from flow in the flow meters and extends down the piping system to various machine outlets; namely -Common Gas outlet Auxiliary O_2 Flow meter Pressure relief valve. The flow meters are important components designed as rotameters calibrated as per the assigned Gas flow, coded differently, having fine control of flows. Downstream in the pipe line have provisions for connecting vapouriors, flow sensors and calibrators. Safety devices are incorporated as part of designing at different levels of machine. The key features of safety system aim to –

1. Prevent administration of Hypoxic Gas mixtures.
2. Prevent Barotraumas.
3. Prevent unintentional administration of excessive Anesthesia concentration.

The flow meter assembly and downstream have following arrangement

1. Mandatory minimum O_2 supply.
2. Link 25 proportionating control system. (3:1:: N_2O:O_2)
3. ORMC (Dragger) O_2 ratio monitor control - Alarm and control.
4. Vapourizers - Agent Specific, Colour Code, Inter locking, keyed filling.

PREANESTHESIA CHECKOUT

Pre Anesthesia checkup and testing – Recommendation for safe Anesthesia

A) Emergency ventilation Equipment: working condition, self inflating- AMBU - bag is available - which can be attached to Auxiliary O_2 supply.

B) Anesthesia machine /work station.

High / Intermediates pressure systems – check[11,12,13,14,15]

1. Check O_2 - Pipeline and Cylinder supply connected - leak proof – adequate (Pr. gauge 1000- 2000 PSI)

2. Turn on machine - Master switch check for Electrical supply - Mains, Battery backup.
3. Disconnect O_2 Supply - Both pipeline and cylinder, push O_2 + flush valve and set low O_2 pressure alarm.
4. Check Fail Safe Alarm - Open O_2 cylinder start O_2 - N_2O flow 5 L/min. Close O_2 cylinder - As the O_2 pressure falls - N_2O flow should automatically come down. Alarms for failsafe and low O_2 pressure will be heard.
5. Reconnect the central pipe line O_2 supply.
6. S*et al*l the Gas flows to zero.

Low pressure system - check

1. Set master switch to stand by position.
2. Perform leak test Open all gas flow valves - as the machine is in standby - there will be no gas flow.
3. Disconnect breathing circuits from machines.
4. Open ACGO (Auxiliary common Gas outlet) and connect bag there.
5. Check vaporizes one by one - check for any leak and interlocking system. All the time the bag should remain deflated. Now remove bag from ACGO - Close ACGO Turn the Main switch on and check display turns on.
6. Test the flow meters and recheck O_2 failsafe. At this time Flow sensor and O_2 Sensor calibration is done. In menu bar - Setup / calibration O_2 Sensor calibration 21.1% Select.
7. Check scavenging System APL valve is open (Adjustable pressure limiting valve)
8. Check suction and all Airway equipments.
9. Routine and Emergency **Drugs** as per check list.

Two Bag Test

1. Machine is switched on = set FGF of 5 Liters first.
2. One bag is reservoir bag on Respiratory system.
3. Second bag - Test lung attach to patient end of Respiratory system / Circuit.
4. Check for unobstructed flow of gas, movement of unidirectional valves.
5. Squeeze both bags - check APL.
6. Ventilate test lung by turning on ventilator.

Checking and Testing of Breathing System: Whole System patent and leak free with correct assembly.

Bain's Circuit: Why? A Unique Hazard is occult disconnection or kinking of inner FGF Pipe - Leads to

1. Entire Corrugated tube becoming dead space.
2. Respiratory acidosis unsuspected / resistant

How to test for Bain Circuit?

(1) Pethick test: To test disconnection or kinking of Inner tube

- Occlude patient end of circuit (elbow connection)
- Close APL valve.
- Use O_2 flush to fill circuit.
- Release occlusion at elbow and flush again, A venturi effect flattens reservoir bag if inner tube (FGF) is patent.

(2) 2nd Test: Occlusion of inner tube at patient end by finger or plunger of 2 ml syringe, - Observe for –

a) A rise in gas pressure in the circuit.
b) Flow meter bobins will dip - because of back pressure effect.

Circle system with CO_2 absorber: Why?

1. To test the integrity of pipes, hoses, canister, sodalime
2. To minimize Apparatus dead space, avoid hypercapnea.

How to test - Circle Breathing System:

1. **Leak Test**: By occluding at y-piece leakage through the system.
2. **Flow Test**: Disconnect Y-piece, blow through inspiratory and expiratory hoses independently to check flow and unidirectional valve.

Workshop

AIM

To train Anesthesia postgraduate students and Anesthesia Technicians for Everyday preanesthesia checkout of Machine and testing of Breathing System.

OBJECTIVES / GOALS

(1) An understanding of Anesthesia machine -

a) O_2 supply system and it's control mechanism.
b) N_2O supply system and it's control mechanism.
c) Volatile Anesthesia Delivery System - Vapourizers
d) Electronic Support System.

(2) An understanding of breathing system that are routinely used –

a) Bain circuit.
b) Circle System with CO_2 absorber.

(3) Demonstration of these features on Demo machine - Mindray – WATO EX-20

(4) Exercising 3 times / training, about machine checking procedure with stressing importance regarding Breathing System's - Testing before starting Anesthesia on each patient.

METHODOLGY

I conducted a 3 day work shop on preanesthesia checkout of Anesthesia machine - Breathing system. A Theory / Demo and hands on training programme on Anesthesia Machine **WATO EX 20** as follows

Day 1: Theory with Demonstration.
Day 2: Hands on training.
Day 3: Assessment and Analysis.

In the morning session on Day -1, the participating 5 anesthesia postgraduate students and 5- anesthesia technicians assembled in the O.T. where WATO EX 20 Anesthesia machine is kept. An introduction to the working, design and utility of the machine is told. Subsequently a detailed description of the machine is done with practical demonstration.

On Day 2: Session I: In the beginning a briefing about the working of Anesthesia Machine is done and a detailed study of hands on testing of breathing system is undertaken.

Session II: The Postgraduate Students and Anesthesia Techniques were grouped in 5 groups. Each of 1 PG student, 1 Technician. All the 5 groups, (I to V) were sequentially called to repeat the test after I demonstrated; while others closely observed. Further a recommended, designed - Preanesthesia checkout list is given for practice.

ASSESSMENT AND ANALYSIS

Next day: In the morning session all the five training groups were asked to practice and repeat Breathing System checking tests on separate 5 WATO EX- 20 Anesthesia machines. Interactive discussion amongst the trainees and teachers was undertaken with question-answer session focusing on importance of preanesthesia checkouts. The feedback forms were given in the following formats.

A) 1) How important is understanding of Anesthesia Machine for uneventful Anesthesia Management.

a) Not important
b) Important
c) Very Important and Essential

2) How much you have understood regarding design and functioning of Anesthesia Machine.

a) Very well
b) Well
c) Not at all

Would you like to further attempt such class to refresh. Yes / No

B) Regarding hands on training for Breathing system testing.

1. Have you understood Bain circuit - components.
2. Bain's Circuit -Tick- What it is ?-
    - It is a coaxial circuit.
    - FGF is near patient End.
    - Outer corrugated tube acts as efferent limb.
    - Reservoir bag and Expiratory valve - near machine end.

2) High flow system: Needs adequate FGF for CO_2 elimination: Yes / No

3) Tick how you will test the circuit

a) Inner tube occlusion test.
b) Outer tube occlusion test.
c) Double test.

Circle system with CO_2 absorber

1. Used with CO_2 absorber System. Yes / No
2. Low flow circuit with conservation of anesthesia gases. Yes / No
3. Testing is done by using 2 bag technique Yes / No

DISCUSSION AND CONCLUSION

Safe Anesthesia Delivery care is essential requirement both ethically and legally. Anesthetising patient is rendering unconscious controlling their reflexes, monitoring and maintaining vital functions. Modern Anesthesia Machines help in great deal. Any malfunction will lead to mishaps, which are directly proportional to morbidity/mortality. The paucity of time during anaesthesia makes it- all too more important to have 100% correct equipment. So PAC systems have been developed-adopted-modified and need to be implemented[16,17,18]. As late as 1993 the importance of well designed PAC (preanesthesia check) was developed and accepted for use. Periodically there have been additional recommendations/ Guidelines for strict documentations of PAC.

GUIDENLINES BY

1. Association of Anesthetists Great Britain and Ireland AAGBI 2012.
2. Association Anesthesiologist of Australia and New Zealand 2014.
3. American society of Anesthesiologist (ASA) guidelines

There have been number of articles in I.S.A. Journals in the Indian context. Despite the importance and need of PAC, the reliability on its practice is not consistant and hence nessaciates review. In this regard a 3 day workshop as Lecture/Training programme regarding understanding of Anesthesia machine and preanesthesia checkup and testing of Routinaly used Breathing System was conducted for 10 Anesthesia personals who are already working in the field of Anesthesia. It is imperative to make pre-Anesthesia checkout and testing, before each Anesthesia and needs every person involved, to master it.[19,20] The interactive method of Teaching - Learning was effective. All the 10 participants realised the importance of knowledge of Anesthesia Machine, Breathing System and their regular checkup before each Anesthesia. They mastered the procedure of Anesthesia Breathing System Testing. Detailed programme of pre- Anesthesia checkup (PAC) needs to be stressed and learnt. PAC should be practised everyday as prayer before starting Anesthesia is each case.

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