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From sample to screen

(A deep dive in to the functionality of ABG machine as a POCT device)

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Abstract. *Arterial blood gas (ABG) analysis is an essential diagnostic tool used in healthcare to evaluate a patient's respiratory and metabolic condition. This article provides a comprehensive overview of ABG machine functionality, its significance in clinical decision-making, and best practices for obtaining accurate results. It explores two types of ABG analyser's, highlighting their accuracy and technological advancements that improve efficiency and reliability. The role of nurses in conducting ABG tests is also addressed, including overview of reinforcement training sessions conducted to enhance their competency. Additionally, the article emphasizes the importance of correct sample handling, interpretation of critical or abnormal values, and timely reporting to ensure optimal patient outcomes. Understanding the correct usage and calibration of the ABG machine enables healthcare professionals to manage critically ill patients more effectively, reinforcing the importance of this technology in emergency and intensive care environments.*

Keywords: ABG Machine, Quality Check, Patient care, Nurses, ABG Sampling.

Introduction

An arterial blood gas (ABG) machine is a critical individual tool used in drug to measure gases and concentrations of various composites in arterial or venous blood; furnishing essential data on oxygenation, respiration and metabolic status. It measures pH, pCo2, po2, HCO3, Ca2, lactate, Na+, K, Cl^-, glucose, Hb, Hct. ABG analysis provide valuable insights into patient's oxygenation, acid-base balance and ventilation status, making it crucial for deterioration and cardiac arrest. ABG analysis is a pivotal skill for nursers, especially those working in critical care, emergency and respiratory units. Nurses, with their great responsibility for patient safety and rights, should be diligent in assessing ABG analysis, acid-base diseases, and the proper management of arterial lines. They should be knowledgeable to accurately identify and report events that routinely occur in complex and dynamic environments like

critical care units. This article insights the operation and QC procedure of two different types ABG analysers and role of nurses in ABG sampling procedure.

SIGNIFICANCE OF ABG ANALYSIS

It may be done one or further of the following reasons.

- Severe breathing and lung problems similar as asthma, cystic fibrosis, or habitual obstructive pulmonary complaint
- Checking on how a case is responding to treatment for lung problem.
- Checking whether a case needs oxygen or other backing with breathing.
- Checking acid- base balance because too important acid in the body may be due to order failure a severe infection specific poisonous ingestion, complications of diabetes or under treated sleep apnea.

COMPONENTS OF ABG ANALYSIS & IT'S CRITICAL VALUES

- **pH:** The pH is the indispensable measure of academia or alkalemia and is therefore an essential part of the pH blood gas measurement.
- **pO2:** The partial arterial oxygen pressure reflects the capability of lungs for oxygen uptake.
- **K+:** The measurement of the concentration of potassium ions in plasma are used to monitor the electrolyte balance.
- **Na+** This reflects the concentration of sodium ion in plasma .it is used to monitor the electrolyte balance.
- **Cl^-** The measurements the concentration of chloride ions in plasma are used to monitor the electrolyte balance.
- **Glucose** -The glucose measures the concentration of glucose in plasma. The glucose measurement is used to screen for, diagnostic and monitor diabetic, prediabetic and hyper and hypoglycaemia.
- **Lactate**: The lactate measurement measures the concentration of lactate in plasma. Lactate measurement serve as a marker of critical imbalance between tissue oxygen demand and oxygen supply.
- **Bilirubin (ct Bil):** When red blood cells age and broken down, the heme group (containing iron) is converted in to bilirubin. Ct Bill is used to assess the threat of hyperbilirubinemia.

Total Haemoglobin: Ct Hb is a measure of potential oxygen carrying capacity of the blood.

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- **Oxygen saturation:** So2 is the oxygenated haemoglobin in relation to the total of haemoglobin in blood. SO2 allows evaluation of oxygenation.
- **Fraction of Oxyhaemoglobin (FO2Hb):** FO2Hb is a measure of application of the implicit oxygen transport capacity; that is the bit of oxyhaemoglobin in relation to all haemoglobins present (tHb) including dyshemoglobins.

- **Fraction of Carboxyhaemoglobin (FCOHb):** It is the fraction of carboxyhaemoglobin that reflects the concentration of carbon monoxide molecules in haemoglobins. It is incapable of transporting oxygen.
- **Fraction of Methaemoglobin (FMet Hb):** FMetHb is the bit of methaemoglobin, a derivative of haemoglobin where the iron within the ferric state, rather than the ferrous state found in normal haemoglobin. It can't bind and transport oxygen.
- **Fraction of Deoxyhaemoglobin in total haemoglobin**: FHHb is the fraction of deoxyhaemoglobin total haemoglobin. It can bind oxygen then forming oxyhaemoglobin.
- **Fraction of fetal haemoglobin (FHbF):** Fetal haemoglobin consists of two alpha chains and two beta chains and has a higher oxygen affinity than adult.

Critical values for ABG parameters

Parameter	Critical Low Value	Critical High Value
pH	≤7.2	≥7.6
pCo_2	≤20	≥70
PO_2	≤40	≥NA
Sodium (Na^+)	≤120 mEq/l	≥160mEq/l
Potassium (K^+)	≤2.5mEq/l	≥6mEq/l
Bicarbonate (HCO_3)	≤10mEq/l	≥40mEq/l
Blood Glucose	≤50mg/dl	≥500mg/dl

Table 1: Critical Values for ABG parameters.

ABG MACHINES AVAILABLE AT INDRAPRASTHA APOLLO HOSPITAL:

There are two types of ABG kept at our hospital.

1 Radiometer ABL 800 2 EPOC ABG

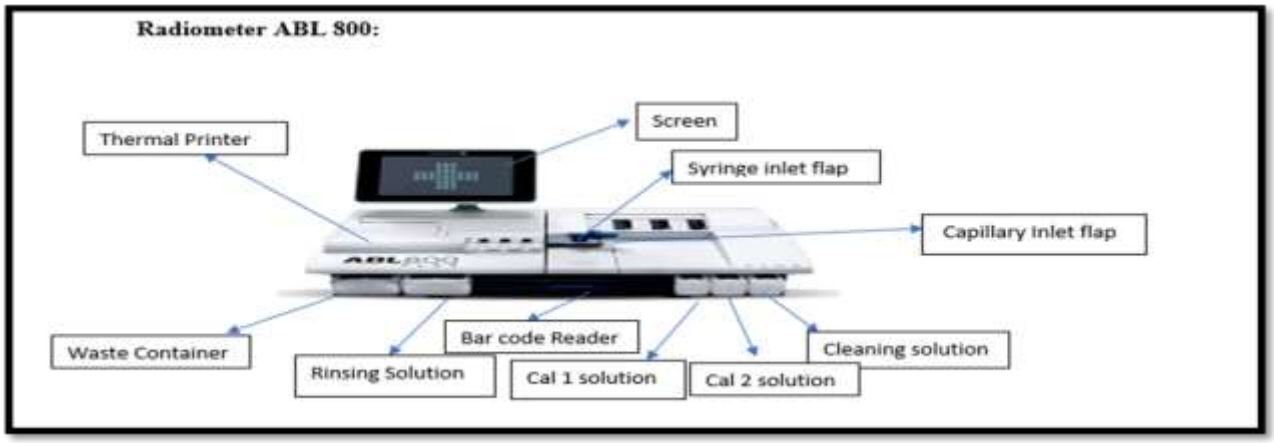

Figure 1: ABG Machine -Radiometer ABL 800.

1.*Radiometer ABL 800 ABG machine*: The Radiometer ABL 800 is a high-performance blood gas analyser. ABL 800 flex offers automated sample handling with drop- n – go functionality, improving work flow efficiency.[1]

Features of Radiometer ABL 800 ABG Analyser

- Easy to operative screen
- Drop- n- Go on the Flex Q
- Additional clinical insight.

Parts description:

- **Thermal printer:** For automatic printout data.

Rinse Solution: It is used for rinsing the liquid transport system after performing various analyser activities.

- **Waste container:** It used for the collection of waste**.** When container is full, it is detected by device and a message is displayed on the screen for replacing waste container.
- **Flex Q module**: It's function to automatically transport of samplers to the inlet.
- **Barcode Reader**: Items that have barcodes can be read into the analyser.
- **Auto check Module**: Contains the auto check ampoules.

Cal 1 Solution: For performing 1 point and 2-point calibration.

- **Cal 2 Solution:** For performing2 point calibrations.
- **Cleaning Solution: It is used** for cleaning the liquid transport system of lipid deposits.
- **Right lever:** To access solutions and pumps.
- **Syringe inlet flap:** It is a hinged or movable part of the machine that allows for insertion of a syringe containing blood sample or QC ampoules.
- **Capillary inlet flap:** Lift to introduce capillary samples.[1]

2. EPOC ABG machine: The EPOC Blood Gas Analysis System is an in vitro diagnostic tool designed for quantitative testing of arterial, venous, or capillary whole blood samples-either heparinized or non-anticoagulated. It supports testing both in laboratory settings and at the point of care. This system is designed to perform a full blood gas analysis at the point of care. It operates wirelessly and utilizes a disposable, room-temperature-stable test card, providing results in less than one minute.

Figure2: ABG Machine –EPOC.

2.1. Features of the device:

- Streamline patient testing workflow.
- Accelerate clinical decision making.
- Deliver real time results and reporting.

2.2. Components: Three are 3 components available in Epoc ABG- Reader, Host mobile computer and BGEM test cards.

Epoc Reader: It has an internal bar code scanner has a card slot for accepting test card, reads test cards during blood test and measures electrical signals from test card sensor. It should be operated at room temperature (15 -30 C). It has an internal temp monitor that will disable its function if the temp falls outside the range. Thus, reader brought in form a warm or cool environment should be allowed to equilibrate before being used.

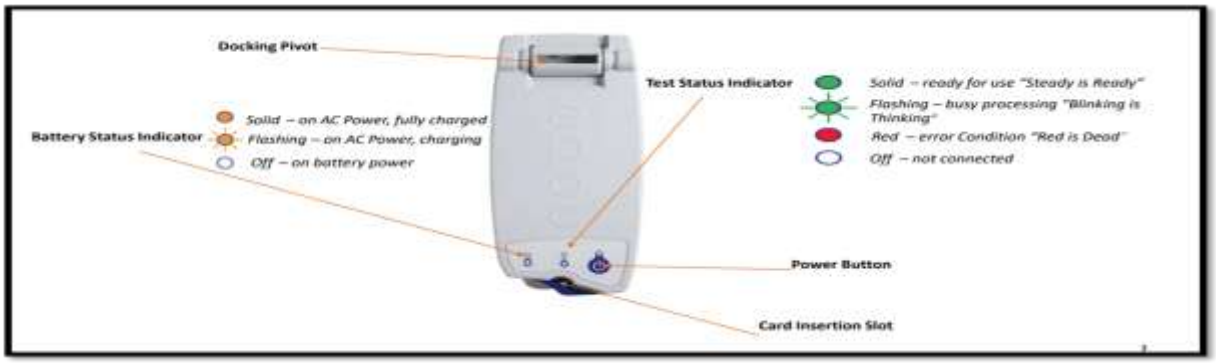

Figure 3: EPOC Reader.

Epoc Host: It is a portable computer with installed host software application. It calculates analytical values from sensor data sent by reader. It displays the test result.

Figure 4: EPOC Host.

Epoc Test cards: These are single-use diagnostic cards equipped with a port for introducing the blood sample. Each card includes a sensor module containing multiple detectors and a sealed reservoir that stores calibration fluid. When a sample is introduced, the system generates electrical signals that correspond to the concentration of specific analytes in the blood.

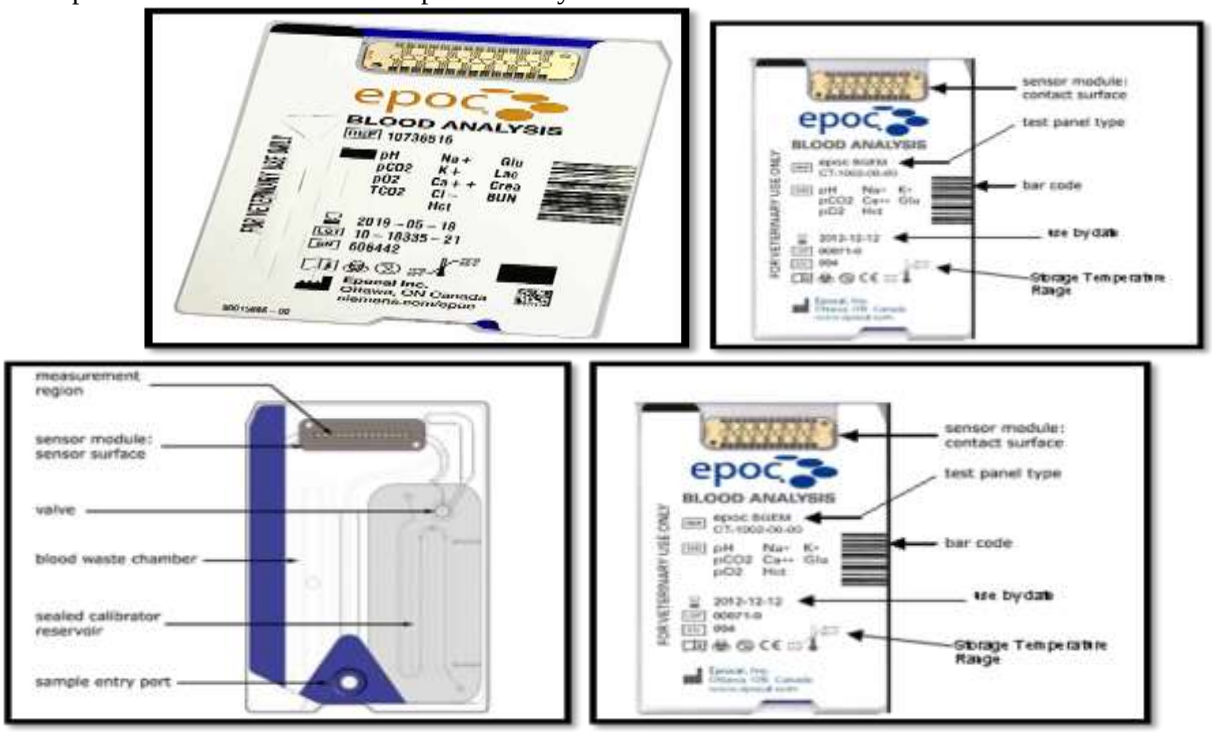

Figure 5: EPOC Test Cards.

Storage requirement:

- BGEM test cards should be stored at room temperature (15C- 30 C).
- Do not throw, drop or shake the cards during handling & storage.
- Do not use a test card if card pouch seal has been compromised in any way.[2]

ROLE OF NURSES IN ABG ANALYSIS

Nursers play a pivotal part in arterial blood gas analysis, which is essential for assessing a case's oxygenation, ventilation and acid base balance.

1. Preparation of patient: Nurses assess the patient's condition, explain the procedure and informed concurrence.

2 Performing Allen's test: Before performing a radial artery puncture, clinicians use Allen's test to ensure sufficient ulnar circulation and adequate blood flow to the hand. The modified Allen test assesses arterial patency and should be conducted before obtaining an arterial blood sample. The steps for performing the test are as follows

A-Instruct the case to grip his or her fist; if the case is unfit to do this, close the person's hand tightly

B-To temporarily restrict arterial flow, apply firm pressure to both the radial and ulnar arteries using your index and middle fingers.

C- If the hand fails to flush within 5 to 15 seconds, it suggests that ulnar circulation is insufficient or absent. In such cases, the radial artery should not be punctured, as it may be the sole source of arterial blood supply to the hand.

Figure 6.1: Allen's Test.

To determine whether the modified Allen test is positive or negative, the occlusive pressure on the ulnar artery should be released.

2.1. Positive modified Allen's test: A positive result occurs when colour returns to the hand within 5 to 15 seconds after releasing ulnar artery pressure, indicating adequate collateral circulation.

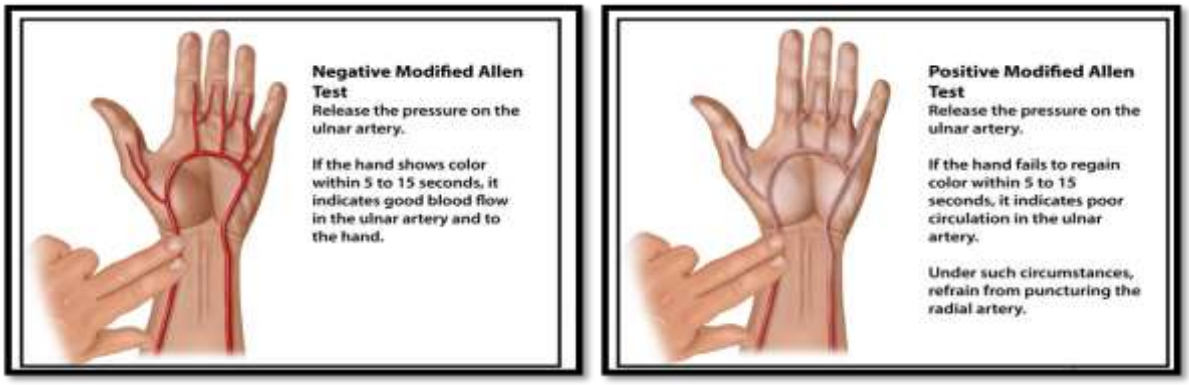

Figure 6.2: Negative & positive modified Allen's test.

2 .2. Negative modified Allen's test: If the hand fails to flush within 5 to 15 seconds, it suggests that ulnar circulation is insufficient or absent. In such cases, the radial artery should not be punctured, as it may be the sole source of arterial blood supply to the hand.[3]

3. Sample collection process:

3.1. Prerequisites before starting sampling:

• Wear sterile gloves during procedure.
• Clean the area with alcohol tar.
• Use only prehepairinzed 1- 2 ml hype.
• Marker the sample hype incontinently with ice pack.

3.2. Sampling procedure steps:

- Position the patient lying flat on their back. Instruct them to breathe normally and remain calm, as actions such as breath-holding or crying can alter respiratory patterns and affect the test results. If the patient is clenching their fist, a rolled towel may be placed under the wrist to stabilize it, particularly if the radial artery is being used for access.[4]
- Detect the radial artery by performing an Allen test for contributory rotation. Repetition of the same process is required on the other hand if radial artery detection is failed in original test.
- Once a point is linked, note anatomical milestones to be suitable to find the point again. If it'll be necessary to flick the point again wear sterile gloves.
- Disinfect the slice point with 70 alcohol and allow it to dry. However, assemble the needle and Ca2 Lyophilized Lithium, heparinized hype and pull the hype Plunger to the needed filler position, If the needle and hype are not preassembled. Holding the hype and needle like an outrage use the indicator cutlet to detect the palpitation again.
- Inform the case that the skin is about to be pierced and also fit the needle at 45- 60 angle roughly. 1 cm distal to (i.e., down) from the indicator cutlet to avoid polluting the area where the needle enters the skin.

- If radial artery is not accessible detect the femoral palpitation and fit the needle at an angle of 90. Avoid perforation of the brachial or femoral artery in cases with lowered or absent distal beats.
- Deficient junking of air bubbles can beget falsely elevated values for the partial pressure of oxygen, to avoid this, the nanny fully removes air bubbles from the hype (vented plunger have an advantage over standard hype in this regard).
- Advance the needle into the radial artery until a blood flush back appears, also allow the hype to fill to the applicable position.
- Do not pull back the hype plunger. After2 mL of arterial blood has been attained, remove the needle. At the same time, use a small piece of reek, held in then on-dominant hand to apply establishment occlusive original pressure at the perforation point until original pressure has been maintained for at least 5 twinkles.
- In cases who have a coagulopathy or are on anticoagulation remedy, it may be necessary to apply original pressure for longer time. Check for haemostasis, and apply a tenacious girth over the perforation point.

Apply an adhesive bandage over the puncture site, if haemostatics is found. Incomplete dismissal of heparin solution from the syringe could cause falsely lone values for the partial pressure of CO2; to avoid this, the nurses should expel all heparin solution from the syringe before arterial puncture unless pre heparinized syringe is used.

- Be careful during the transport of syringe from patient's site to laboratory. Contact between air and arterial blood sample can be prevented by covering the syringe with one hand scoop method.
- Dress the perforation point. preventives need to be taken during Sampling When slice, it's pivotal to take preventives to ensure delicacy, help impurity, and maintain safety. Then are some crucial preventives to follow
- Reach to the ABG device for analysing the sample as foremost possible.

4. Monitoring for complications: Nursers watch for bleeding, hematoma or arterial spasm and give immediate intervention if demanded.

5. Introducing samples into the device:

5.1. In Radiometer ABL 800-

Figure 7: Sampling process in Radiometer ABL 800 ABG Machine.

5.1.1 Steps for sample introduction:

- Make sure that the **"Ready"** mode is displayed and all parameters' flashes green on the screen.
- Lift the syringe inlet flap, select **"syringe"** for syringe sample and **"capillary"** for capillary sample.
- Place the syringe and touch the start key.
- Select the desired mode for different sample volume modes.
- Touch the **"aspirate"** key.
- Wait for the msg **"close inlet".**
- Remove the syringe and close the inlet flap after receiving the msg.
- Wait for print out of sample report.
- Patient ID can be entered by the user before or after sampling process.[5]

5.2. In Epoc ABG:

- Start the reader & the host by pressing on- off key.
- Log in to host software application connect wirelessly to the reader from the host (as applicable).
- The display shows Pat ID. Enter patient UHID here.

Figure 8.1 Log in Process in EPOC ABG. Figure 8.2 Patient Details Entering Process.

The display prompt "**Insert test card to begin test**". Now, take a new test card from the pouch an immediately insert it into the base of the reader. This will start the calibration period for the test card. The reader will flash green light and the host will display this msg **"Calibrating. Do not inject samples."**
Use the 165 seconds calibration period to entire patient information select tests and sample type (if applicable).

Figure 8.3: Insertion of Test card.

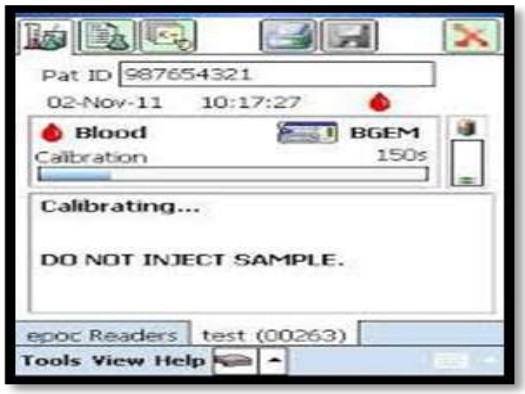

Figure 8.4: Calibration process.

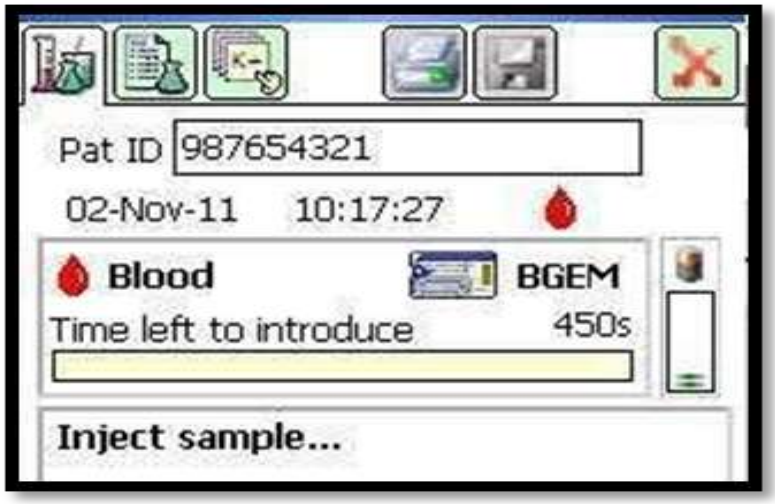

Figure 8.5: Sample injection.

Collect blood samples. After calibration is completed, the green light on the reader will turn steady and the host will display "Inject Sample". The blood sample can be introduced into the test card now. The sample may be introduced at any time during 450 seconds (7.5 minutes) period after calibration.

The card is no longer available to accept a sample after this duration. The reader automatically analyses the test sample within half a minute and displays the result on the screen. The results are grouped as gases electrolytes and metabolites. Printout of the result can be taken. Remove the test card and discard it as a biohazard waste in the specific colour coded disposal bag as per state biomedical waste management guidelines. Fresh blood sample taken from arterial venous or capillary sources is introduced to the test card from syringe or EPOC capillary tube. Sample Volume at least 92 micro l.

5.2.1 Steps for sample introduction:

Step 1: Hold the syringe barrel vertically between finger tips and thumb. Keep syringe vertical and perpendicular to the test card to avoid sample spillage.

Step 2: Secure the tip of the syringe into the centre recess of the blood sample entry port of the test card by using slight downward pressure. Swirl the syringe up to ¼ turn to ensure a good seal. The user should feel the syringe tip engage with the rubber seal of test card entry port.

Step 3: While maintaining downward pressure, use index finger of the other hand to steadily depress the syringe plunger with a single, smooth, continuous motion until prompted to stop. An audible beep is produced by reader and the green indication is flashed in the indicator.

Sample for analysis was received. The host also displays sample acceptance.[6]

Figure 8.6: Introducing the sample into the test card.

6. Interpreting Results: Nurses assist in analysing ABG values to assess oxygenation, ventilation and acid base balance, guiding clinical decisions.

6.1. Critical value reporting protocol: Critical value if found to be immediately informed to the assigned doctor and documented in the read back sticker (Blue). As well as in nurse's notes.

6.2. Abnormal value reporting protocol: If there is an abnormal value for a patient (drastic change in the trend of patient's measured value (but not in the critical value range) to be informed to the assigned doctor immediately and action to be taken accordingly. To be documented in nurse's notes as well.

During quality control checks, if the measured value is out of range/not passed, repeat checking to be done twice; if the problem still persists inform to concerned Lab and Biomedical Department immediately & to be documented in the quality control record books.

7. Post procedural care: They ensure proper site care, apply pressure to prevent bleeding, and educate patient's on after care.

Quality check procedure of ABG analyser:

8.1. Qc in Radiometer ABL 800: The purpose of quality control is to authenticate the analyser's performance by evaluating accuracy and precision. Performing quality control will help to ensure that results from actual patient samples are accurate. Each quality control system includes four types of control solutions to assure analyser performance when measuring parameters at low, normal and high levels.

Control solutions are packed in ampoule box contains an inset with the radiometer -determined assigned values and control limits valid for particular lot of control [7]

To begin Qc:

- Click on 'Menu 'option on touch screen then click on 'start 'programs then click on "Auto check Programs".
- Click on 'Run selected' after selecting control levels.
- Result is available on the screen after the completion of QC performed by the device.

Quality control frequency:

NO. OF SHIFTS	QUALITY CONTROL FREQUENCY
3	One level is tested at the beginning of each shift. The 4Th level is tested in the shift with the maximum volume of patient sample.
2	Two levels are tested at the beginning of each shift.
1	All levels are tested at the beginning of the shift

Table 2: Quality control frequency in Radiometer ABL 800 ABG Machine.

Figure 9.1 Quality Control Ampoules.

Figure 9.2 Quality Control Ampoules. Boxes

8.2. Quality assurance in Epoc ABG: Verification of BGEM test cards is done using 3 control solution named as level 1, level 2, level 3. These are available in ampoules. If ampoules are taken from cool storage, equilibrate the ampoules to room temp (20- 25C) for four hours minimum for a full box and for

one-hour single ampoules outside of the box. When the lot no. of BGEM card is changed run a quality check with at least two levels of control solutions.

8.2.1. Steps:

Turn "on" the reader and the host. Login to host software application. Connect the reader from the host wirelessly. Select "Tolls" after that select "switch to QA test "from selection menu. Take a new test card from the pouch and immediately insert it into the base of the reader. This will start the calibration period for the test card. The reader will flash green light and the host will display this msg. **"Calibrating. Do not inject sample".**

Figure 10 Calibration process before injecting QC ampoules.

Use the 165 second calibration period to enter the QC lot number and select test (if applicable) After calibration is complete the green light on the reader will turn steady and the host will display **"inject sample".**

8.2.2. Introducing the control sample into the test card: Hold the ampoules between the thumb and forefinger shake it vigorously for at least 15 seconds to re-equilibrate gases with the solution.

Twist the ampoules gently to return the solution to the bottom of the ampoules. Allow bubbles to rise.

With the intention to preserve gases in the control fluid, transfer the fluid from the ampoules into a plain syringe by slowly aspirating it through a large bore needle or blunt tip without any delay. Inject the QC fluid into the test card without any delay. Once the analysis is complete, approximately 44 sec after sample introduction the host displays the test result from the reader screen. Compare the result with the given control solution range. Repeat the above steps with another level control solution. If the results are out of range repeat QC process again. If the results are still not in the given range, send the device to biochemistry lab.[8]

REINFORCEMENT TRAINING SESSIONS ON ABG MACHINE FOR NURSING STAFF:

Through a blend of theoretical instruction and hands on experience nurses were guided to enhance their proficiency in using ABG Machine ensuring improved patient care & safety. To equip nurses with the necessary skills and confidence to operate the ABG machine effectively, a dedicated sessions were conducted.

Figure 11: Glimpses of Reinforcement sessions on ABG Machines.

SUMMARY

In summary, the arterial blood gas (ABG) machine is an indispensable tool in modern medical diagnostic providing rapid and accurate analysis of critical blood parameters. It's ability to assess a patient's respiratory and metabolic status in real time makes it essential in emergency care, intensive care units and surgical settings. By enabling timely clinical decisions, the ABG machine significantly contributes to improved patient outcomes. **As technology advances, future development may further enhance it portability, automation and integration with electronic health records making it even more efficient and accessible in diverse healthcare environment. As such, the ABG machine continues to play a pivotal role in improving patient outcomes and advancing modern healthcare.**

ACKNOWLEGEMENT

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