Original article:

OXIMECH

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Abstract:

Purpose: According to a study published by the WHO for the year 2011-12, 45% of the worldwide post-natal deaths occur due to Infant respiratory distress syndrome or Birth hypoxia. The main cause of this is the failure of the lungs to oxygenate the blood in the infant's body. The lungs' alveoli and their surface area allows diffusion of oxygen from the air to the bloodstream where haemoglobin molecules carry it to the body's tissues. When this process is unable to fully oxygenate the blood using the 20% of oxygen in air, additional oxygen can help. Higher concentrations of oxygen lead to faster diffusion into the blood stream. Nowadays medical grade Oxygen Concentrator's are installed in hospitals which use zeolites for extracting oxygen from the atmosphere and provide it to the patients in a well monitored manner. These processes are highly costly and very complicated. A place where the availability of resources is low, lack of equipment and very high cost can make providing high concentration oxygen difficult for the newly born leading to death. We propose a unique and novel product OXIMECH which is a low cost, robust and highly efficient way of providing higher concentration of oxygen to the infants. OXIMECH is designed in such a way that the poorest of the poorest person can avail the facility of it in any corner of the earth.

Design/Methodology: OXIMECH implements a simple technique of pressure regulation using pistons in a threefold compartment system. The oxygen is produced using electrolysis. The atmospheric gas is fed in compartment A and a 1:1 mixture of H2 and O2 (products of electrolysis) gas in compartment B. The desired proportion of gases is finally fed into the final compartment C where the pressure can be maintained and regulated. It enables the user to have any desired partial pressure of Oxygen in the to-be provided gas. Compartment C is reusable in nature and can be transported to any place where it is needed. This unique and easy-to-use product is portable with lightweight, transferrable and recyclable cylinders.

Findings: Our work showcase the use of simple and low cost mechanical contraptions to replace the current Oxygen Concentrator's used only in large hospitals and health centres with OXIMECH which is capable of providing with high concentration of oxygen to every individual in need during emergency. This will help us to overcome the deaths due to Birth hypoxia especially in the rural areas.

Originality/value: OXIMECH is a highly efficient product which can produce higher concentration of oxygen in transferrable and recyclable cylinders. These can be installed in Primary Health Centres(PHCs) all over the country from where people can take the oxygen cylinders with them. OXIMECH is designed in such a way that the production and maintenance costs should be very low.

We believe that paying 10$ for an oxygen cylinder is like paying the almighty rent for creating us.

Introduction

According to a study published by the WHO for the year 2011-12, 45% of the worldwide post-natal deaths occur due to Infant respiratory distress syndrome or Birth hypoxia. The main cause of this is the failure of the lungs to oxygenate the blood in the infant‟s body. The lungs' alveoli and their surface area allows diffusion of oxygen from the air to the bloodstream where haemoglobin molecules carry it to the body's tissues. When this process is unable to fully oxygenate the blood using the 20% of oxygen in air, additional oxygen can help.

Birth hypoxia occurs in about four of every 1,000 full-term births. It may be even more common when babies are born prematurely.

The amount of harm to the newborn depends on how long and how severe the period of hypoxia is, and how quickly the right treatment is given. Two stages of injury can happen with birth hypoxia. The first stage happens within minutes without oxygen. Cell damage occurs with the initial lack of blood flow and oxygen. The second stage of damage is called "reperfusion injury" and can last for days or even weeks. This injury occurs after restoration of normal blood flow and oxygen to the brain, and is due to toxins released from the damaged cells.

Babies with mild or moderate hypoxia may recover fully. Babies whose cells did not get enough oxygen for a longer time may have permanent injury to their brain, heart, lungs, kidneys, bowels or other organs. When a premature baby has hypoxia, the damage may lead to cerebral palsy, developmental disabilities, attention deficit hyperactivity disorder or impaired sight. In the most severe cases, hypoxia can lead to organ failure and death.

To overcome this problem additional oxygen is supplied. Higher concentrations of oxygen lead to faster diffusion into the blood stream. Nowadays medical grade Oxygen Concentrator‟s are installed in hospitals which use zeolites for extracting oxygen from the atmosphere and provide it to the patients in a well monitored manner. These processes are highly costly and very complicated. A place where the availability of resources is low, lack of equipment and very high cost can make providing high concentration oxygen difficult for the newly born leading to death. We propose a unique and novel product OXIMECH which is a low cost, robust and highly efficient way of providing higher concentration of oxygen to the infants. OXIMECH is designed in such a way that the poorest of the poorest person can avail the facility of it in any corner of the earth.

OXIMECH follows a simple technique of pressure mapping using pistons in a triple compartment system. The oxygen is produced using electrolysis. The atmospheric gas is fed in one compartment and pure oxygen gas (product of electrolysis) gas in another compartment. The desired proportion of gases is finally fed into the final compartment where the pressure can be maintened and regulated.

It enables the user to have any desired partial pressure of Oxygen in the to-be provided gas. The final compartment is reusable in nature and can be transported to any place where it is needed. This unique and easy-to-use product is robust with lightweight, transferrable and recyclable cylinders.

Needs being met

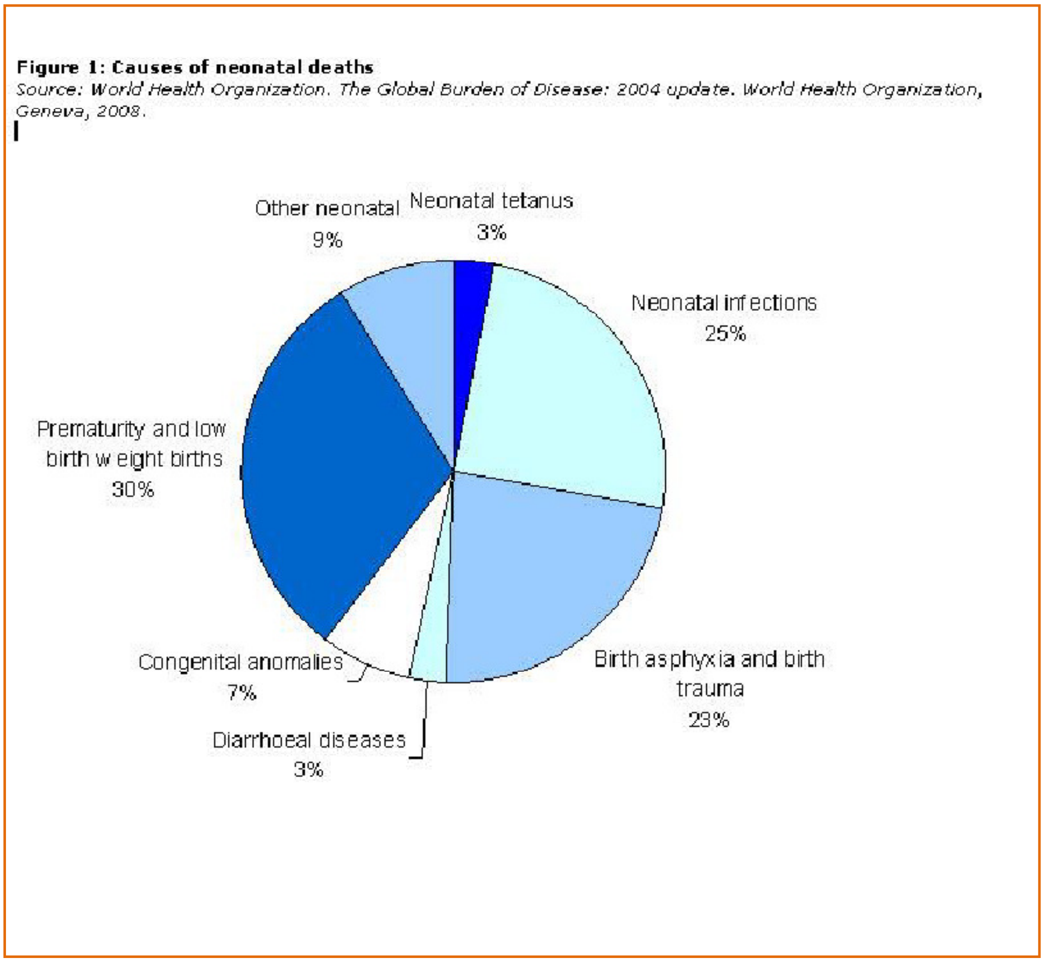

Figure 1

Key facts

 Every year nearly 40% of all under-five child deaths are among newborn infants, babies in their first 28 days of life or the neonatal period.

 Three quarters of all newborn deaths occur in the first week of life.

 In developing countries nearly half of all mothers and newborns do not receive skilled care during and immediately after birth.

 Up to two thirds of newborn deaths can be prevented if known, effective health measures are provided at birth and during the first week of life.

The vast majority of newborn deaths take place in developing countries where access to health care is low. Most of these newborns die at home, without skilled care that could greatly increase their chances for survival.

Skilled health care during pregnancy, childbirth and in the postnatal (immediately following birth) period prevents complications for mother and newborn, and allows for early detection and management of problems. In addition, WHO and UNICEF now recommend home visits by a skilled health worker during a baby's first week of life to improve newborn survival. Newborns in special circumstances, such as low-birth-weight babies, babies born to HIV-positive mothers, or sick babies, require additional care and should be referred to a hospital.

Newborn, or neonatal, deaths account for 40% of all deaths among children under five. The majority of all neonatal deaths (75%) occur during the first week of life, and between 25% to 45% occur within the first 24 hours. The main causes of newborn deaths are prematurity and low-birth-weight, infections, asphyxia (lack of oxygen at birth) and birth trauma. These causes account for nearly 80% of deaths in this age group. A low cost oxygen concentrator would increase the chances in saving the lives of the infants.

Existing solutions

Oxygen is generally separated out from air using a zeolite column. This can happen at the bedside, at the hospital level, or at centralized processing facilities. Bedside concentrators allow tubing to supply oxygen to the patient. Hospital-level concentrators will be piped to individual wards. Alternatively, oxygen can be compressed and bottled for use near the patient. Oxygen bottles are also often used as backup for hospital systems.

At the patient, this high oxygen concentration gas will be mixed with air to provide the appropriate level to the patient. An adult might need 3 litres per minute while a neonate may need less than one. It is important to adjust oxygen levels specifically for a patient as oxygen dissolved in the blood but not attached to haemoglobin is toxic and can lead to blindness in neonates through retinopathy.

Current Use in High-Resource Settings Well-equipped hospitals typically have O2 piped to wards as well as backup concentrators or cylinders in place. Patients are monitored to ensure their oxygenation is appropriate using pulse oximetry. Oxygen is readily available in both labour and delivery wards as well as for neonatal resuscitation and wards.

Application in Low-Resource Settings Where O2 is available in low-resource settings; it is mostly by concentrator and O2 cylinders. Where power is available, concentrators are often more economical than cylinders in the long run. A single oxygen source can be used in a patient ward to support several patients simultaneously where necessary. Lack of equipment and staff can make monitoring oxygen levels difficult.

Make	Model	Price	Technology
AIRSEP	NewLife	$1100	Stationary concentrator
MEDLINE	Nidek Nuvo Lite	$630	Portable concentrator
INSPIRON	Diatom	High capital cost	Custom system and installation
GENERIC	6000L	$565	Cylinder w/reg & flow

Proposed idea

OXIMECH implements a simple technique of pressure regulation using pistons in a threefold compartment system. The oxygen is produced using electrolysis. The atmospheric gas is fed in compartment A and ~100% O2 (products of electrolysis) gas in compartment B. The desired proportion of gases is finally fed into the final compartment C where the pressure can be maintained and regulated. It enables the user to have any desired partial pressure of Oxygen in the to-be provided gas. Compartment C is reusable in nature and can be transported to any place where it is needed. This unique and easy-to-use product is portable with lightweight, transferrable and recyclable cylinders.

Description

The whole apparatus is divided into 2 major parts as follows:

1. Electrolysis setup

A specific Steel container containing Water (H20) and Sulphuric acid (H2SO4) in ideal proportions is supplied with a minimal electrical energy source*. The Anode and Cathode are kept apart such that the Oxygen gas (O2) evolved at anode is fed to the following container and care is taken that the Hydrogen gas (H2), which is evolved at cathode is vented out without mixing with the Oxygen gas thus, making it a pure source. Hence, we are deemed to obtain ~100% of Oxygen gas.

It is provided with inlet for „Water" and „Sulphuric Acid".

*Electrical energy source could be and AC mains, Battery or even a dynamo.

2. Cylinder setup

It consists of 3 steel cylinders- A, B and C, each of the dimensions of 50cm X 15cm and connected to each other as shown in figure 2, with polymer piping. The cylinders contain air-tight pistons to push/pull the air. The piping is provided with gating components to voluntarily alter the flow of air. Valves are installed at the mouth of each cylinder which helps increasing the pressure and at the same time maintain unidirectional flow and prevent regurgitation.

The inner base of each cylinder is provided with barometer to measure the pressure of the gas present in the container with its volume being measured by the piston movement.

CYLINDER-A: Oxygen Collector

Collects all the Oxygen gas produced in the electrolysis and maintains its pressure and volume.

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CYLINDER-B: Atmospheric air collector and Proportionating Unit

Collects the atmospheric air (21% Oxygen gas and 78% Nitrogen gas) and maintains its pressure and volume.

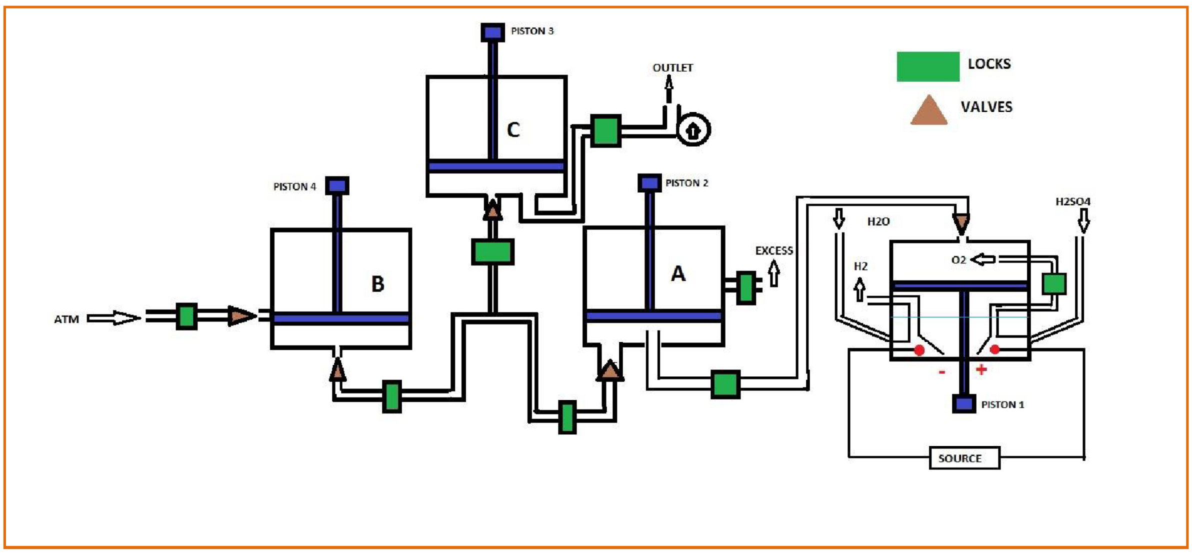
CYLINDER-C: Assumes the mixture of gas from Cylinder-A and Cylinder-B of desired proportion, most ideal for the patient.

Has an outlet vent to remove excess air and a pressure regulator to maintain the desired outflow pressure and rate of flow.

Detachable cylinders could be used so as to make it portable in nature.

SCHEMATIC DIAGRAM:

Figure



WORKING:

The „Electrolysis Unit" produces Hydrogen (H2) gas and Oxygen (O2) gas. The Hydrogen gas is vented out and Oxygen gas is kept in the container. Once adequate pressure potential is developed, piston-I is used to push the air into the Cylinder-A via valve-I. The piston-II is pulled to contain the gas. The electrolysis is then continued until the piston-I assumes its original zero position and the whole process is repeated until the desired volume of gas is present in Cylinder-A.

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NOTE: The power source used for the purpose of electrolysis can be AC mains power supply, a battery or a dynamo.

Simultaneously, the Cylinder-B is prepared by pulling in atmospheric air and keeping it at required pressure and volume. This is used in situations where 100% oxygen is not always required.

NOTE: This part is completely optional i.e. only when a medium concentration (21%-85%) of oxygen is required. For cases where > 90% of Oxygen is required, it need not be used.

Once Cylinders-A and B are ready, the gates are opened to let the air flow into Cylinder-C while simultaneously pulling piston-III and reverting piston-I and piston-II. Thus, the Cylinder-C is prepared in a similar procedure as Cylinders-A and B. The pressure regulator at the outlet maintains the outflow pressure and can be altered.

It can be used while attached or can be detached and taken to the site of requirement.

NOTE:

Pressure sensors installed on the base of the pistons gives the user the information about the pressure of the gas present in the container.

Also, a scale attached on the shaft of the piston makes the user aware of the total volume of gas present.

Novelty of idea:

Why it's new??

- Mechanical contraptions never used
- Availability of easily available electrical sources (Batteries, dynamos..) (making it easy to use in rural areas)
- Electrolysis of water used to produce high concentration oxygen.
- Use of cheap building material like steel with inert coating (from oxygen).
- Source of oxygen is water which is abundant in nature.
- Gaseous products of this design are eco-friendly, non-polluting and are not harmful for nature.

Differences	OXIMECH	Existing products
Portability	High, Ready to use cylinders can be carried to the required location	most of the products are not portable
Mode of operation	Use of batteries, dynamos, AC mains for electrolysis. Pressure maintenance in mechanical mode.	Complete system based on electricity
Development cost	Very low	High development cost
Operating cost	low	high
Variability of oxygen level	Can be changed by the user according to the requirement	fixed

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Feasibility of idea:

Technical feasibility

OXIMECH is operated on a mechanical basis which makes is very easy to use. It is designed in such a way that anyone can learn to use it in a very ample amount of time. The source of power can be batteries which are easily available. Dynamos can also be used to recharge the equipment.

Engineering feasibility

The materials required for the manufacturing of OXIMECH easily available and abundant in nature. The cylinders are made up of steel which is available at a low price of Rs.42 per kg in India. Use of steel makes OXIMECH durable because of it anti-rusting property and cheap at the same time. Piping is also done with steel preventing any leakages of air. Pistons are used for pressure mapping in OXIMECH pistons are easily to handle and the pressure in the cylinders thus can be effectively monitored. Valves are used for controlling the flow of gases in the equipment making the proportions accountable. The electrolysis setup is made up of specific Steel container containing Water (H20) and Sulphuric acid (H2SO4) in ideal proportions is supplied with a minimal electrical energy source.

Implementation

OXIMECH can be installed at places like Primary Health Centres (PHCs) in rural areas from where the needy can carry the oxygen cylinders to their homes at a very cheap price. It can also be installed at community levels as the cost is very low.

AFFORDABILITY

OXIMECH can be available at a very low price of Rs.5000 as compared to the existing products like AIRSEP, MEDLINE etc. whose starting price is more than Rs. 20,000 which is too much for a person with low income to afford. The recharge price of current oxygen cylinders is almost Rs. 700. OXIMECHs oxygen cylinders can be availed at a much cheaper rate of Rs.50. The manufacturing and operating costs OXIMECH is almost 75% lower than the current oxygen concentrators.

Value proposition:

OXIMECH

Cylinder

Weight = 10kg

Cost of steel per kg = Rs. 42

Cost of each cylinder = Rs. 420

No. of cylinders = 4

Cost of cylinders = 420 x 4 = Rs.1680

Piping = Rs.1000

Pistons = Rs.1500

Gating &Valves = Rs.500

Total cost of OXIMECH = Rs. 4680

CONCLUSION

Reducing the cost of oxygen concentrators by 75% will make it accessible to a very large portion of the population. This will help us to curb the problem of lack of oxygen at birth for the newborns (Birth Asphyxia) which constitutes almost 25% of the causes of total neonatal deaths.

The device is completely mechanical in nature and requires precision on the user‟s part to operate. Here the cylinders need to be charged before use. Although, on the brighter side, with very few cost additions, it can be completely automated and may not even require any manual operation except for restoring water and sulphuric acid.

References:

This is an innovative article written by students without quoting any references.

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