Open Journal of Neurology & Neuroscience

Short Communication
Published: 04 Oct, 2023

Cost Benefit Analysis of LOX *vs.* PSA

Bhattacharya T*

Military Hospital, Kirkee, India

Introduction

Economic evaluation of one over the other is important. More so when the costs are continuously rising to tide over scarcity of resources. Getting one has its own checks and balances – some seen and some unseen [1]. Cost benefit analysis is the most comprehensive method of economic evaluation among others. While USA emphasized the benefit of Cost-Effective Analysis (CEA) in 1980, about three decades later the Harvard is reaffirming the importance of Cost Benefit Analysis (CBA) [2]. In terms of the diktat issued by the Office of Technology Assessment- cost benefit analysis sums up all the costs and benefits are valued in monetary terms while in cost effective analysis the gain is calculated in other units (years of life gained- QALY or DALY) [3]. The role of analyst is not only to influence the decision maker but also the decision-making process that has assent of the community as a whole and the impact will affect the masses [4].

The next perspective is of the pandemic caused by the coronavirus SARS-CoV-2 in 2019 end - spreading right from Wuhan, China to spread across borders. The masses succumbed to the virus- although nothing very great, but the rate of spread shook the healthcare institutions to their basic foundations irrespective of caste, creed, race, economies and stature. The reason?

The main reason for failure of hospitals was the volume of cases. The cases were of acute respiratory distress syndrome in varying stages of severity with or without end organ involvement due to intravascular coagulation/hypercoagulable state. Treatment protocols were changing and evolving from 2019 right up to 2022 (Table 1).

The mainstay of the therapy included oxygen right from the beginning of the pandemic. Nonetheless to mention the necessity of the gas for sustenance of operation theatres, and other vital processes of the hospital but sustaining them during the pandemic what's the question. The arrival of patients of various severities landed the hospital administrators into serious trouble. While acute patients on ventilation required 100% oxygen at pressure of 4 atmospheres, the less severe ones needed oxygen at much lesser pressures.

The amount of oxygen dependent on the following set of delivery devices [5]:

Nasal Prongs	(25-45%)
Face Masks	(15-60%)
Non-Respirator Breather Masks NRBM	(55-95%)
High Flow Nasal Cannula	(70-100%)

The concentration of oxygen supplied to the patients varied according to their severity. The essential function of the life force of oxygen is beyond the scope of this paper. The clinical decision of discontinuing pure oxygen to the patients, preventing the low levels of carbon dioxide for respiratory stimulation is not being discussed here.

Supply of oxygen to the patients by the various modes of delivery warranted an essential availability of either liquid or gaseous oxygen. The equipment's used for supplying oxygen to the

Table 1: Treatment protocols in COVID.

Group of Pharmaceuticals used in COVID	Initial use/remarks	Sustainable? Still in use
Oxygen	+++++	+++
Steroids	+++	+
Antibiotics	+++++	+/-
Immunomodulators	+++++	-/+
Bronchodilators	+++++	+

OPEN ACCESS

***Correspondence:**
Bhattacharya Tarapranava, Military Hospital, Kirkee, Pune, India

Received Date: *21 Jul 2023*
Accepted Date*: 29 Sep 2023*
Published Date*: 04 Oct 2023*

Citation:
Bhattacharya T. Cost Benefit Analysis of LOX vs. PSA. Open J Neurol Neurosci. 2023; 1(1): 1004.

***Copyright** © 2023 Bhattacharya T. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

Table 2: Modes of oxygen delivery.

Parameter	Oxygen concentrators	Oxygen cylinders	Oxygen Generation Plant	Liquid Oxygen tank
Purity	90-96%	99.90%	91-96%	100%
Supply chain	Non expendable. Procurement constraint multifactorial.	Non expendable resources. Filling of cylinders dependent on civil resources.	Huge machine installed in hospital premises.	Depends on the supply chain for filling.
Cost (Rs.)	20,000.00-50,000.00	750.00-20,000.00	>40,00,000.00	>50,00,000.00
Advantage	Easier to install/use	Transport of oxygen dependent patients	Independent of supply chain, costlier but stable investment	Pure oxygen available to patients.
Limiting factor	Availability in market	Replacement inescapable	Electricity support to non-critical patients only	Availability of liquid oxygen in vicinity and supply chain management.

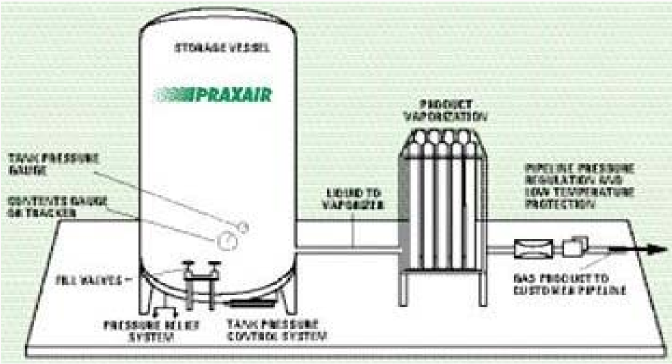

Figure 1: Cryogenic oxygen tank.
The boiling temperatures are: Liquid Oxygen -297.3°F | -183°C
Three layered coat: Inner stainless-steel coat-exposed to cryogenic temperatures; Middle insulating layer along with vacuum to withstand pressures; Outer layer of carbon steel or stainless steel.

Figure 2: Oxygen generation plant.
Components: Air compressor, Filter, Air dryer, Air filter, PSA system, Storage tank, Supply to patient end through manifold

hospitals range from handy oxygen concentrators, oxygen cylinders [of various capacities], the hefty oxygen generation plant to the costly liquid oxygen tanks. While the oxygen concentrator and the oxygen generation plant function to use the atmospheric air by removal of other gases like nitrogen, carbon dioxide, etc. through a chemical adsorption on the other hand pure oxygen is supplied by the other two modes. It is essential to mention the types of oxygen cylinders here namely medical oxygen and industrial oxygen cylinders.

The various modes of oxygen supply are tabulated below

The modes of Oxygen supply to the patient care areas are through Manifold gas pipeline. Hospitals used many of these modes (as depicted in Table 2) for delivery of oxygen to the patients. Failure of one and success of the other varied from place to place and situations likewise. Instances of fire accidents, failure of supply chain management of oxygen and shortage of delivery devices was taken seriously at higher administrative echelons. Next came the government directives on availability of oxygen plants in medical college hospitals mandatorily [6].

Relevance of the cost benefit study is to verify how effective the dictum stands

Cost benefit analysis and cost-effective analysis are the 2 types of studies undertaken to evaluate investments. While cost benefit study analyses the investments and the takeaways in monetary terms, the cost-effective analysis compares decision alternatives in non-monetary benefits [7]. Cost benefit analysis is the most comprehensive and theoretical sound way of economic evaluation and has been used for decision making in many social/economic fields [8].

The costs and benefits in this perspective can be discussed as under-

A. Equipment intensive hospitals need to value patients. The costlier the investment, the higher will be the proportion passed on to the patient bills. The higher the bills, increased out of pocket expenditure will play havoc with lives of people.

Table 3: Table showing comparison of total oxygen consumption and patient bed days.

Month	Patient bed days	Number of patients admitted in a month	Oxygen consumption (cu mtr)
March-20	1	1	-
April-20	107	6	-
May-20	186	19	-
June-20	1161	155	-
July-20	5371	623	-
August-20	6160	407	20741
September-20	6648	538	26416
October-20	3902	228	14650
November-20	484	30	3820
December-20	330	23	7041
January-21	324	30	3493
February-21	299	34	3726
March-21	1069	153	6245
April-21	3234	432	35300
May-21	4317	386	87203
June-21	1245	98	25479
July-21	787	75	13430
August-21	830	84	19538
September-21	986	66	14519
October-21	339	27	10416

B. Hospitals which don't delve into expensive investments will have to deal with resource crunch at times of adversity, inability to treat patients effectively, higher morbidity/mortality and eventually bad name/foul reputation.

C. Heavy investments made, patients treated, motive solved but the next scenario is not so many cases. Idle generators and machines would occupy space and represent blocked capital (opportunity lost).

The situation is thence a Catch 22 moment. The endeavor is to give a view of investments made by more than one hospital during the pandemic of COVID in 2020-22.

Higher income countries

Integrated oxygen plants with majority hospitals makes them self-reliant. Foolproof oxygen supply to beds in acute care areas, chronic and isolated in-patient areas remain a strong point. As for the supply chain of consumables, medical gasses and requisites remains well within limits considering the infrastructure of countries like US, UK, France, Sweden [9].

Low/Middle income countries

For countries like India, China, Brazil and many African nations the Covid times had a number of lessons. Investment in engineering teams, electromedical and sophisticated equipment came to focus along with the importance to development of general infrastructure (Figure 1).

Mandatory clearances

- Clearance of 3 mtr (any type of construction/ traffic
- Clearance of 5 mtr from all types of flames and inflammable substances
- All statutory requirements of the Chief Controller of Explosives of India and SMPV rules need to be followed; besides all regulations and guidelines put forward by the State/UT competent authority
- Civil work & PESO approval (Online application)
- Fencing & gate around the installation.
- Fire extinguisher, water connection, lighting, safety signages, earthing pit for lightening arrestor.
- Allocated space for installation should be 9M (W) × 16M (L)
- Site should be selected at ground level, outdoor, without overhead power or other utility cable.
- Should have assigned space for smooth movement of LMO tanker from/to the installation.
- Display of liquid oxygen level and outlet gas pressure should be provided.
- Automatic change over should be provided between the LMO tank and existing oxygen manifold in the health facility premises.

Important points

Runs on electricity. So, the compressor has to work continuously. Duplicate system may be installed to provide rest period to the machines.

De-humidifier is an important installation till the patient end and should be continuously monitored. Sophisticated electromedical equipment like ventilators frequently succumb to moisture (Figure 2).

Aim

To carry out cost benefit analysis of installation of oxygen generation plant versus liquid oxygen plants in hospitals

Objectives

(a) To analyze the oxygen consumption of oxygen in a tertiary care super specialty hospital.

(b) To determine costs of installation of an oxygen generation plant based on Pressure Swing Adsorption technology and a cryogenic oxygen tank.

(c) To compare the costs over benefits and give suitable recommendations.

Methodology

Cross sectional study

Place of Study- Pune

(a) Data collected from AFMS hospitals in different Command Zones.

(b) The capital cost off the equipment.

(c) Source of funds- central/local procurement/corporate social responsibility.

(d) Expenditure incurred in installation of the equipment.

Table 4: HOSPITAL A: Cost of liquid oxygen plant.

Item	**Cost (Rs)**
Equipment Cost (inclusive of Shipping charges, 05 years AMC 05 years	55,00,000.00
Land (Govt owned land)	0
Water supply and electricity charges	0
Liquid oxygen (@ Rs.24 per cu mtr)	5,87,580.00
Manpower	6,60,000.00
Total	**67,47,580.00**

Table 5: HOSPITAL A: Cost of oxygen generation plant.

Item	**Cost (Rs)**
Equipment Cost (inclusive of Shipping charges, 05 years AMC 05 years	1,05,00,000.00
Land (Govt owned land) preparation of platform with surrounding cover	93,00,000.00
Water supply and electricity charges	1,05,000.00
Manpower	6,60,000.00
Total	2,15,65,000.00

Table 6: HOSPITAL B: Cost of liquid oxygen plant.

Item	**Cost (Rs)**
Equipment Cost (inclusive of Shipping charges, 05 years AMC 05 years	55,00,000.00
Land (Govt owned land)	0
Water supply and electricity charges	0
Liquid oxygen (@ Rs.17 per cu mtr)	34,00,000.00
Manpower	6,60,000.00
Total	95,60,000.00

(e) Usage of the equipment and benefits.

(f) Comparison of the data in respect of both the equipment.

Exclusion criteria- private hospital.

Inclusion criteria- hospitals that have recent installation of Oxygen tanks/generators.

Observations

Data was collected from

(1) Chief ward master office – number of COVID patients admitted during the calendar month.

(2) Patient bed days were calculated adding the actual occupancy load which required oxygen supplementation in some form.

(3) Medical store- the record of total liquid oxygen topped up during each month (Table 3).

Ascertaining costs for installation of oxygen generation plant and liquid oxygen tank

Hospital A (Table 4, 5)

Comparison

Cost of Oxygen Generator Plant (OGP)/Cost of Liquid Oxygen Tank (LOX) = 2,15,65000/67,47,580 = 3.19.

Hospital B (Table 6, 7)

Comparison

Cost of Oxygen Generator Plant (OGP)/ Cost of Liquid oxygen tank (LOX) = 2,47,65000/95,60,000 = 2.5.

Table 7: HOSPITAL B: Cost of oxygen generation plant.

Item	**Cost (Rs)**
Equipment Cost (inclusive of Shipping charges, 05 years AMC 05 years	2,40,00,000.00
basement of high-rise building G+7	0
Water supply and electricity charges	1,05,000.00
Manpower	6,60,000.00
Total	2,47,65,000.00

Table 8: HOSPITAL C: Cost of oxygen generation plant.

Item	**Cost (Rs)**
Equipment Cost (inclusive of Shipping charges, 05 years AMC 05 years	94,29,000.00
Land (Govt owned land) fitted in the	0
Water supply and electricity charges	1,05,000.00
Manpower	6,60,000.00
Total	1,01,94,000.00
Cylinders refilled in 08 h	20
Number of cylinders needed in 12	4000
Cost of refilling cylinders (Rs.525 per cylinder)	21,00,000

Hospital C (Table 8)

Comparison

Cost of Oxygen Generator Plant (OGP)/Cost of cylinders refilled in 12 months = 1,01,94,000/21,00,000 = 4.8.

Interpretation

Hospital C procured the Oxygen Generation Plant with an extra adjustment for filling of cylinders.

The vulnerability of refilling of cylinders was surpassed with the training of own hospital staff to refill cylinders at own time.

Threat- Cylinders filled up from the Oxygen Generation plant had only 90% to 92% purity which might prove useless in few cases requiring high dose of oxygen.

Summary

1. Oxygen consumption in hospital can be forecasted but is difficult in scenario of extreme vulnerabilities.

2. Oxygen Generation plant is an important investment making the hospital independent of supply chain logistics for oxygen cylinders/refilling of tank. But the inability of the machine to supply 98% pure oxygen makes it unsuitable for operation theatres as well as treatment of acute ill.

3. Liquid medical Oxygen tank on the other hand is expensive but still lesser on comparison. Although the tank is savior for acute care areas of hospital, it is heavily dependent on private industries for filling up liquid medical oxygen.

References

1. Wagle K. Economic evaluation, types of economic evaluation! Health Economics. 2017.
2. Culyer AJ, Chalkidou K. Economic evaluation for health investments En route to universal health coverage: Cost-benefit analysis or cost-effectiveness analysis? Value Health. 2019;22(1):99-103.

3. Office of Technology Assessment. The implications of cost-effectiveness analysis of medical technology. 1980.
4. Sugden R, Williams A. The principles of practical cost-benefit analysis. 1978.
5. Steffan NM. Understanding noninvasive ventilation. 2021.
6. Sharma N. Oxygen plant made must for new medical colleges.
7. Belfield C, Levin HM. Cost–benefit analysis and cost–effectiveness analysis. International Encyclopedia of Education (Third Edition). 2010;199-203.
8. Robinson R. Cost-benefit analysis. British Medical Association. 1993;307(6909):924-6
9. Smith L, Baker T, Demombynes G, Yadav P. COVID-19 and oxygen: Selecting supply options in LMICs that balance immediate needs with long-term cost-effectiveness. 2020.