Application of Modern Management Techniques in Healthcare

S G

Abstract

Health is the right of every individual and its awareness is a must to all citizens of the country. In an era of cost-intensive medical care, every equipment being installed in health care institutions need to be fully and properly utilized. Administrators of a hospital must select the method that can be used to greatest advantage, bearing in mind the original expenses and the cost of maintenance. Use of liquid medical oxygen (LOX) at hospitals has become increasingly common in the present day situation chiefly due to economic considerations as also promising intangible benefits. Use of modern management techniques in the medical field is relatively a recent development and can aid in future cost containment. Cost benefit analysis is formal analytical method to provide a rational, objective means of comparing total costs with total benefits. The Aim of the study: To study the cost benefit analysis (CBA) in using liquid medical oxygen (LOX) as against oxygen concentrators and oxygen manifold system at a large tertiary care hospital. The Objectives included, (1).To study the cost incurred in maintaining the oxygen concentrators and the manifold system as against LOX. (2). Assess the tangible & intangible benefits in use of liquid medical oxygen.

Methodology: The methodology adopted was a retrospective study for a period of six months compared against a prospective six month study in the same time of the year. Use of liquid medical oxygen ensures quality in delivery of patient care. Results: The study revealed that with the use of liquid oxygen there is 26.6% reduction in volume of medical oxygen consumption along with a 38% saving in overall costs, realized due to its usage. It can also be inferred that an increase in the utilization of liquid medical oxygen can lead to increase percentage of savings on costs. Limitations: In arriving at the expenditure incurred in the usage of oxygen concentrators and manifold, it was unable to arrive at the exact number of electrical units consumed by the same due to absence of an electrical meter; however the units are calculated based on the motor power.

INTRODUCTION

Hospitals of the present era no more provide just curative services. With increasing health awareness there is increase in the number of hospitals as also patient visits and admissions. Rising healthcare costs have posed a challenge to administrators to run the system more efficiently. Better control techniques and innovative ideas have to be adopted in ‘cost centers’ of the hospital to prove efficiency. Maintaining an oxygen-bank is a cost centre and round the clock availability of medical oxygen is vital for the hospital functioning. Supplemental or “extra” oxygen is one of the most widely used therapies for people admitted to the hospital. It is also frequently used for patients with chronic lung disease who live at home. The importance of oxygen therapy for many patients with heart and lung diseases is universally recognized.1

With the increase in understanding of the benefits of oxygen and other forms of therapy through inhalation, inhalation therapy became progressively more important, in the care of patients in hospitals.2 Within a few years, hyperbaric oxygen proved effective against anaerobic infections, most notably gas gangrene.3

The methods of administering oxygen must be accurate, efficient and economical. The administrator of a hospital must select the method that can be used to greatest advantage, bearing in mind the original expenses and the cost of maintenance. To provide a replacement piece of equipment, which will meet the medical needs of the hospital at a reduced cost, is a goal that is infrequently obtained.4 In an era of cost-intensive medical care, every equipment being installed in health care institutions need to be fully and properly utilized. An optimum utilization of equipment will result in:

- Minimum possible costs.
- Quality patient care and satisfaction.
Liquid oxygen is a bluish transparent, magnetic liquid obtained by compressing gaseous oxygen. Liquid oxygen is a cryogenic liquid. It has a boiling point of – 297.3 °F (-183 °C). It cannot exist as a liquid at a temperature higher than –118.38 °C irrespective of the pressure. Oxygen is stored as a liquid though it is primarily used as a gas. Liquid storage is less bulky and less costly than the equivalent capacity of high-pressure gaseous storage.

Cost-Benefit Analysis: The common-sense principles of CEA/CBA (cost-effectiveness/cost benefit analysis) have been promoted for centuries. In 1902, the River and Harbor Act directed the Corps of Engineers to assess the costs and benefits of river and harbor projects. In 1936, the Federal Flood Control Act required that “the benefits (of projects) to whomsoever they may accrue must be in excess of the estimated costs” though the Act provided no guidance as to how benefits and costs were to be defined and measured. In the period of a decade, society’s principal health system goal has shifted from increasing access to health care to controlling the rapidly inflating costs of care. The dilemma is in containing costs without sacrificing desired benefits such as improved access to health care and quality.

The cost benefit analysis and cost effectiveness analysis are formal analytical methods to provide a rational, objective means of comparing total costs with total benefits. The use of these techniques in the medical field is a relatively recent development and can aid in future cost containment.

Many economists have proposed a hospital economic model divided into two parts, one where clinical decisions are taken and other where the administrators manage scarce economic resources. The relationship between these two parts should explain hospital performance. All the resources of the staff, equipment, space, and materials can be more productively used. This can lead to reduction in costs per unit of service and increase in marginal surplus of production. Hospital costs as defined by Hansen and Penderson are “Cost is consumption expressed in monetary units of services and goods necessary for production, which are the institute’s outcome.”

The hospital under study is a 1400 plus bedded multi specialty, tertiary care hospital. The need for a more accurate and efficient method of supply of oxygen at reasonable rates was felt, and hence it was decided to go for liquid source. The Liquid oxygen tank with a capacity of 11,450 liters was installed in November 2002. Keeping the objectives of cost and benefits, both to the patients and to the hospital it was decided to make a comparative study of liquid medical oxygen over other sources of oxygen in use by the hospital.

Aim: To study the cost benefit analysis (CBA) in using liquid medical oxygen (LOX) as against oxygen concentrators and oxygen manifold system at a large tertiary care hospital.

OBJECTIVES

• To study the cost incurred in maintaining the oxygen concentrators and the manifold system as against LOX

• To assess the tangible & intangible benefits in use of liquid medical oxygen.

Methodology: The methodology adopted include both prospective & retrospective. The Liquid Oxygen Plant at the tertiary care hospital, was studied for a period of 6 months from January to June 2003. The methods used are:

PROSPECTIVE STUDY

Interviews: Direct informal interviews were conducted with the oxygen plant in-charge and staff working at the plant. Direct informal interviews were held with the engineers and staff of the company, responsible for maintaining and functioning of the liquid oxygen plant instillation.

Cost-Benefit Analysis: The various cost factors involved in the implementation of liquid oxygen was calculated by obtaining information from the purchase and finance departments. This was measured against the realized savings because of Liquid oxygen.

Cost per M³ of oxygen was done separately for liquid oxygen, oxygen concentrator and oxygen manifold.

RETROSPECTIVE STUDY

A retrospective study was done by review of the,

Communication files maintained in the administration office, pertaining to tank installation, terms and conditions of the purchase, maintenance of the installation etc.

Office records pertaining to the functioning of oxygen concentrator and problems encountered in its maintenance was perused.

Records with regard to number of purchases and consumption of oxygen through manifold, maintained at the plant site were studied.
Observation and Discussion: Medical oxygen for therapeutic use in hospitals is nowadays available in two forms, as compressed gases in bulk cylinders and as cryogenic liquid stored in vacuum insulated containers. However the mode of administration is inhalation therapy. Administration of medical gases through a central piped system at our tertiary care hospital started in the year 1990 with the use of oxygen manifold. Later with the increase in bed strength and bed utilization, requirement of medical oxygen for patient care also increased and an Oxygen Concentrator (OC) was installed in 1996. However use of liquid medical oxygen (LOX) at hospitals has become increasingly common in the present day situation chiefly due to economic considerations as also promising intangible benefits.

**CALCULATION OF EXPENDITURE**

The cost of the oxygen concentrators, purchased in the year 1996 for Rs. 27, 777/-, which included installation charges.

Depreciation was calculated @ 10% per annum by straight-line method assuming that the effective life span of the equipment is 10 years.

The maintenance of the equipment is by Annual Maintenance Contract, with the cost of spares being borne by the hospital.

The electricity consumption by the concentrators was worked based on the motors capacity used to run the concentrators.

During the calculation charges for water was not considered, as there was no consumption of water as such and meant for circulation only.

Staff salaries are also not taken to account, as there was no increase or reduction in the staff strength prior to after installation of cryogenic vessel.

Consumption of oxygen through bulk cylinders for a 6-month period is calculated by going through issue/receipt register.

**CALCULATION OF POWER CONSUMPTION:**

The cost of single unit of electricity, @ Rs. 5.20/-

The capacity of the motor used to run the concentrator is 30hp, this being used for 20 hrs per day

Power consumption by both the concentrators per day is 480 Units of electricity.

**CALCULATION OF OXYGEN PRODUCTION BY CONCENTRATORS:**

Hourly production of oxygen by the concentrators on an average is about 10 Cubic meters.

Daily production of oxygen @ 20 hrs of running per day is 200 Cubic meters.

Procurement of volume of oxygen in 6-months (Jan ‘02 to June ‘02):

Procurement of Oxygen through cylinders is 58,829 Cubic meters.

Oxygen production by concentrators is 36,200 Cubic meters.

Total oxygen (procured +produced) is 95,029 Cubic meters.

**PROCUREMENT OF VOLUME OF OXYGEN IN 6-MONTHS (JAN ‘03 TO JUNE ‘03):**

Procurement of liquid Oxygen is 54,690 Cubic meters.

Procurement through bulk cylinders is 14,997 Cubic meters.

Total oxygen procured (bulk +LOX) is 69,687 Cubic meters.

Comparing the volume of procurement between the time frame of January to June 2002 and January to June 2003, there is about 26.6% decrease in the volume of procurement, although the volume of activity with in the hospital remained almost the same. This was reflected through the daily census and the Bed occupancy during the periods.

The decrease in the volume of procurement can be attributed to reduction in the usage of bulk cylinders; almost 7% of medical oxygen is lost as residual volume in bulk cylinders, which cannot be utilized. Secondly, oxygen produced by the concentrator is first stored in a storage chamber before it is distributed through the central supply lines. Sometimes excess of oxygen produced, exceeding the storage capacity is vented out into the atmosphere in order to maintain pressure with in the tank. Use of liquid oxygen has helped in overcoming these drawbacks (See Figure-01), by ensuring complete utilization of the liquid without any significant loss through venting unlike oxygen concentrators.
Comparing the above two tables it can be concluded that there is a marked reduction in the expenditure for procurement of bulk cylinders during the period of Jan to June 2003. This is because of bulk cylinder usage strictly restricted to the wards and areas without central line supply, unlike the period during oxygen concentrator supply when the main operation theater and also the Intensive care units, made use of bulk cylinders in order to get the desired level of oxygen concentration for patient care.

In determining the cost of a product or service two types of expenditure are involved. These are direct and indirect costs,
associated in running a particular service or any particular unit of activity. Direct costs are usually subdivided into the groups, which are labour costs, material costs and direct expenses. In contrast indirect costs are a kind of joint product expenses, which cannot readily be identified wholly as having been incurred on any one activity. These are also called “Overhead expenses or Overheads and sometimes as On-costs”.

**Figure 5**
Table: 03- Shows costs incurred for procurement of Medical Oxygen installation of Liquid Oxygen Tank (LOX)

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Particulars of Costs</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>January '02 to June '02</td>
<td>Bulk Oxygen cylinders</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost of oxygen (including Kst)</td>
<td>Rs.10,69,407/-</td>
</tr>
<tr>
<td></td>
<td>Transport charges @ Rs 800/- per trip (93 trips undertaken in 6 months)</td>
<td>Rs.74,400/-</td>
</tr>
<tr>
<td></td>
<td>Rent for 50 cylinders @ Rs 1/- per day</td>
<td>Rs.9000/-</td>
</tr>
<tr>
<td></td>
<td>TOTAL =</td>
<td>Rs.11,52,807/-</td>
</tr>
<tr>
<td></td>
<td>Oxygen Concentrator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed costs:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual maintenance contract (for 6 months)</td>
<td>Rs.1,09,000/-</td>
</tr>
<tr>
<td></td>
<td>Electricity consumption @ Rs. 5.20 per unit</td>
<td>Rs.4,49,280/-</td>
</tr>
<tr>
<td></td>
<td>For oxygen concentrators</td>
<td>Rs.749/-</td>
</tr>
<tr>
<td></td>
<td>For tube lights</td>
<td>Rs.1,36,388/-</td>
</tr>
<tr>
<td></td>
<td>Depreciation @ 10% per annum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variable costs:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spares &amp; maintenance charges</td>
<td>Rs.11,547/-</td>
</tr>
<tr>
<td></td>
<td>Consumption of oil for 30 lit @ Rs. 63.43p</td>
<td>Rs.1,903/-</td>
</tr>
<tr>
<td></td>
<td>TOTAL =</td>
<td>Rs.6,99,667/-</td>
</tr>
<tr>
<td></td>
<td>Money spent on Medical Oxygen =</td>
<td>Rs.18,52,474/-</td>
</tr>
</tbody>
</table>

Note: Bulk cylinders on rental basis were not procured as the hospital was self-sufficient with existing bulk cylinders in stock.

From the above table the savings incurred in 6 months is calculated to be Rs. 6,99,920/-.

The annual savings is estimated to be ≈ Rs.13,99,840/-.

Savings realized due to usage of liquid oxygen is calculated as:

**Figure 6**
Table: 04- Shows costs incurred for procurement of Medical Oxygen installation of Liquid Oxygen Tank (LOX)

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Particulars of Costs</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>January '03 to June '03</td>
<td>Liquid Oxygen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost of oxygen @ Rs 7.90 per m³</td>
<td>Rs.4,32,051/-</td>
</tr>
<tr>
<td></td>
<td>Kar sales tax @ 12%</td>
<td>Rs.54,125/-</td>
</tr>
<tr>
<td></td>
<td>Delivery charge @ Rs 2,10p per m³</td>
<td>Rs.1,14,849/-</td>
</tr>
<tr>
<td></td>
<td>Rent for installation @ Rs 800/- per day</td>
<td>Rs.1,44,800/-</td>
</tr>
<tr>
<td></td>
<td>TOTAL =</td>
<td>Rs.7,45,025/-</td>
</tr>
<tr>
<td></td>
<td>Money spent on Medical Oxygen =</td>
<td>Rs.11,52,554/-</td>
</tr>
</tbody>
</table>

From the above calculation it can be estimated that there is a savings of ≈ 38% on costs incurred in procuring oxygen.
In the study above the total costs incurred in 6 months during the same time period is compared, and measured against the benefits (tangible and intangible). The savings realized was because of Liquid oxygen. Further savings on expenditure may be possible if the central medical gas network is expanded to all areas of the hospital.

The oxygen consumed through bulk cylinders during January-June 2003 in hospital areas lacking central supply is 14,997 cubic M$. In replacing this volume with LOX the expenditure the procurement would have been Rs. 1,64,186/- (including taxes & delivery charges) apart from a onetime investment of nearly Rs 4,50,000/- as fixed costs. The six monthly savings on oxygen procurement is Rs. 2,43,343/- (≈ 60% savings on cost as against use of bulk cylinders).

The intangible benefits availed are:

Supply of oxygen for patient care is always 99.9% pure unlike in oxygen concentrators where there is always a fluctuation in the level of oxygen purity, the maximum purity being only 90-94%

Due to continuous supply of liquid oxygen, the pipeline pressure is almost always constant, there by providing no hindrance to patients availing oxygen in OT’s and in ICU’s and other patient care areas.

The environment around the hospital is patient friendly with less noise and heat generated with use of liquid oxygen reservoir, unlike oxygen concentrators resulting in improved patient quality of life.

With features of central monitoring system and fixing of safety stock for the liquid levels, there is no need for an alternative source of oxygen required.

With usage of liquid oxygen there is requirement of only one staff at the plant site to record the pressure and liquid level of oxygen on an hourly basis unlike in oxygen concentrator and cylinder manifold usage, which requires strict vigilance.

Liquid oxygen does not consume any electricity unlike concentrators, leading to reduced expenses and also

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**Figure 8**
Figure 02: Percentage savings on cost in procuring medical oxygen

**Table-5: Estimated cost of expanding central pipeline to all areas of the hospital**

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Complete specifications</th>
<th>a/i</th>
<th>Qty</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total length of 10mm dia 19 swg copper pipeline with T-elbow &amp; braising</td>
<td>Mtr</td>
<td>51</td>
<td>18,980.00</td>
</tr>
<tr>
<td>2</td>
<td>Total length of 16mm dia 19 swg copper pipeline with T-elbow &amp; braising</td>
<td>Mtr</td>
<td>321</td>
<td>1,40,604.00</td>
</tr>
<tr>
<td>3</td>
<td>Total length of 28mm dia 19 swg copper pipeline with T-elbow &amp; braising</td>
<td>Mtr</td>
<td>146</td>
<td>1,00,704.00</td>
</tr>
<tr>
<td>4</td>
<td>Outlet point</td>
<td>Nos</td>
<td>54</td>
<td>48,600.00</td>
</tr>
<tr>
<td>5</td>
<td>Isolation valve for 16cm pipe</td>
<td>Nos</td>
<td>07</td>
<td>9,990.00</td>
</tr>
<tr>
<td>6</td>
<td>Isolation valve for 28cm pipe</td>
<td>Nos</td>
<td>04</td>
<td>5,550.00</td>
</tr>
<tr>
<td>7</td>
<td>Single BPS flow meter with humidifier</td>
<td>Nos</td>
<td>06</td>
<td>6,600.00</td>
</tr>
<tr>
<td>8</td>
<td>Double BPS flow meter with humidifier</td>
<td>Nos</td>
<td>48</td>
<td>96,000.00</td>
</tr>
<tr>
<td>9</td>
<td>Oxygen mask</td>
<td>Nos</td>
<td>102</td>
<td>6,600.00</td>
</tr>
<tr>
<td>10</td>
<td>Connection to mainline 28mm pipe</td>
<td>Nos</td>
<td>1</td>
<td>500.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1,4,7,710.00</strong></td>
</tr>
</tbody>
</table>

**Figure 10**
Figure 03: Showing various costs involved in procuring oxygen in 2002

In switching over to the liquid oxygen from the oxygen concentrator and manifold system there is a total savings of 38% on the amount being spent and reduced work load for the staff present at the plant site. Richard and Mcferguson (9), states that all the resources of the staff, equipment, space, and materials can be more productively used. This can lead to reduction in costs per unit of service and increase in marginal surplus of production. For non-profit hospitals this surplus can be used for further development of hospital.
overcomes power cuts.

Since the cryogenic tank is installed on rent, the initial investment borne by the hospital is minimal or practically nil.

With the company owning responsibility for maintenance of the cryogenic liquid, the hospital has overcome the maintenance costs unlike in oxygen concentrators.

It is noted that even empty bulk cylinders have some residual oxygen, which cannot be utilized; this wastage is overcome with use of liquid oxygen.

The liquid oxygen is supplied twice in a month in bulk; this saves on transport charges unlike in use of bulk cylinders where there is an average of 15 trips in a month with frequent orders.

By going through the record it is evident that the concentrators had to undergo very frequent maintenance programs (avg. 45 days) in order to keep the equipment functioning. However during the period of study there has been no major breakdown hampering the functioning of the oxygen plant. The purity of oxygen obtained was a maximum of 94%, which was inadequate for undertaking OT surgical procedures.

Limitations: During the usage of oxygen concentrator there was no separate electric meter to record the electrical units consumed. The number of electrical units consumed is calculated based on power consumed by the motor on which the equipment runs.

CONCLUSION

The study of cost-benefit analysis on oxygen plant at a multi-speciality hospital reveals that, with the use of liquid oxygen there is a reduction in the periodicity of bulk cylinder procurement and also associated with a 27% reduction in volume of medical oxygen procurement. (Note: The volume of activity in the hospital being same throughout the period of study).

The 38% savings in overall costs realized due to usage of liquid oxygen can be attributed to savings incurred on cost involved in maintenance of concentrators, electricity and transportation charges for procuring bulk cylinders. It can also be inferred that an increase in the utilization of this liquid source of medical oxygen can lead to further savings on costs. Expanding the central medical gas piping network to all areas of the hospital can bring about achieving this goal. An estimated cost in expanding the central medical gas piping network (this included copper pipes of various diameters/lengths, L-shape & T-shape bends and flow meters and labour) was worked out to be Rs. 4,27,710/-.

Liquid oxygen source brings about intangible benefits like; steady supply of 99% purity of oxygen for patient care, with absolutely no noise in the vicinity of patient care area. Another benefit is the ability to function without electricity maintaining quality in patient care. No responsibility for maintenance of the facility. Finally need for an alternative source does not exist except for a manifold serving as a back-up required rarely.

References

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4. McGibony J.R.No.384, Principles of Hospital Administration
7. Information Specific to Liquid Oxygen, July 2003
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