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# A Study on Oxygen Utilization Pattern And Costing In Critical Care Units And Operation Theatre oA Rural Tertiary Care Hospital.

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***Abstract:*** *Supplemental Or Extra Oxygen Is One Of The Most Widely Used Therapies For Patients Admitted To The Hospital. In View Of Its Increasing Demand, An Observational Descriptive Study On Medical Gas Supply System In A Rural Tertiary Care Hospital Was Undertaken With An Objective To Study The Utilization Pattern And Costing Of Oxygen In Critical Care Units And Operation Theatre For Improving Efficiency Of Medical Gas Supply System In The Hospital.*

*The Hospital Under Study Is A Large Tertiary Care Teaching Hospital Rendering Healthcare Services To Rural Population And Has A Well-Established Central Medical Gas Supply System Functioning Effectively.*

*The Ventilator Hours, The General Anaesthesia Hours In Operation Theatre And Direct Oxygen Utilization In Critical Care Units Were Studied For Six Months, From May To October 2015.*

*Expenditure On Oxygen For Those Months Was Studied And It Corresponded With The Utilization Pattern, September Being The Month With Maximum Oxygen Utilization (19%) Hence Maximum Expenditure Followed By October (18%) And July (17%).*

*It Was Concluded That Intensive Care Unit Is The Area With Maximum Average Oxygen Consumption (43%) Followed By Respiratory Intensive Care Unit (31%). Average Cost Of Oxygen Per Patient Per Day In Critical Care Areas Was Calculated And Worked Out To Be Highest In ICU (Rs. 2704.19) Followed By RICU (Rs. 1932.17)*

***Keywords :*** *Costing, Oxygen, Utilization.*

## I. Introduction

Gases administered to patients are called medical gases. A centralized medical gas system is increasingly becoming an essential requirement in hospitals. The centralized medical gas system provides an efficient, economical and dependable medical life support network that supplies medical gases, vacuum and compressed air to operating and special procedure rooms.[1] Medical gases are supplied in compressed gas cylinders and piped to wards and critical areas through complex systems collectively known as the Medical Gas Pipeline Services (MGPS).[2] Pipelines serve as a convenient and economical method for the distribution of medical gases when compared to cylinders.[3]

Oxygen is the best known of all medical gases. Oxygen was discovered by Scheele and Priestley—the agent ubiquitous in modern medicine.[4] Antoine Lavoisier, named the gas oxygène, meaning acid former, in 1778.[4]The first recorded medical use of oxygen was on March 6th, 1885 in York, PA by Dr. George Holtzapple, who used oxygen for the treatment of pneumonia.[5]

Liquid oxygen is derived by the fractional distillation of liquid air. One volume of liquid oxygen yields 842 times of its volume of oxygen in gaseous form at 15°C temperature and one atmospheric pressure.[6]

In view of the increasing demand for oxygen in hospitals, centralized distribution has become necessary. The non-interruption of oxygen supply is said to be more vital than any other service in the hospital.[7] In large hospitals where the consumption of oxygen is very high it is convenient, economical and space saving to replace the cylinders with liquid oxygen.[8] Supplemental or extra oxygen is one of the most widely used therapies for patients admitted to the hospital. The importance of oxygen therapy for many patients with heart and lung diseases is universally recognized.[9] Oxygen is also used for anaesthesia. Hence utilization of oxygen can be best studied by calculating number of ventilator hours, general anesthesia hours and hours of direct inhalation.

Hence, keeping in view the above points, a study on the oxygen utilization pattern in critical care units was conceptualized and undertaken.

## II. Aim & Objective

To study the utilization pattern and costing of oxygen in critical care units and operation theatre of a rural tertiary care Hospital.

## III. Materials and methods

**3.1 Study setting**: Department of Hospital Administration, Kamineni Institute of Medical Sciences, Sreepuram, Narketpally. It is a multi-specialty teaching institution having 1090 beds, established in the year 1999 and rendering healthcare services to a large population, mostly rural. It has a well-established medical gas supply system that supplies medical gases, vacuum and compressed air to its critical care units and operating rooms. All the components of medical gas supply system which include manifold room, pipeline system, terminal units and monitoring and alarm systems are present.

**3.2 Study Design: Observational Descriptive study.**
**3.3 Study period: From May 2015 to Oct 2015**
**3.4 Methods:**

**a.** Direct observation of oxygen utilization for patients admitted to critical care areas for a period of six months to arrive at average consumption of oxygen per patient per day, by perusing the information from the registers maintained in the concerned critical care areas, showing the rate of flow and hours of oxygen that was given to the patients.
**b.** Ventilator hours in critical care units and Litres of gaseous oxygen utilized calculated at rate of 6 lit/min
**c.** General anaesthesia hours in operation theatre and Litres of gaseous oxygen utilized calculated at rate of 6 lit/min
**d.** Perusal of records for calculating costs incurred

**3.5 Areas included in the study are**

Critical care areas selected for study and their Bed strength is: ICU – 6, AMC – 10, POW – 23, RICU – 3, EMD – 30, PICU – 10, NICU I – 6, NICU II – 5, Labour room – 10, OT – 12 operating rooms, pre op beds – 5 and recovery beds – 5.

## IV. Observations

**4.1 Utilization of oxygen**

It has been studied in critical care areas and operation theatre under the following headings:

- Ventilator hours in critical care units
- General anaesthesia hours in operation theatre
- Direct utilization in critical care areas through mask/nasal catheter

**4.1.1 Table 1:** Ventilator hours in critical care units and Litres of gaseous oxygen utilized

| Area | May 2015 | June 2015 | July 2015 | August 2015 | September 2015 | October 2015 | Total hours |
|---|---|---|---|---|---|---|---|
| ICU | 1012 | 1163 | 2647 | 2791 | 2435 | 1987 | 12035 |
| POW | 423 | 648 | 720 | 453 | 76 | 208 | 2528 |
| NICU I | 24 | 240 | 192 | - | 270 | 346 | 1072 |
| NICU II | - | 144 | - | - | 71 | 120 | 335 |
| PICU | 115 | 264 | 216 | 24 | 43 | 9 | 671 |
| AMC | - | - | 5 | 136 | 261 | 37 | 439 |
| EMD | 26 | 17 | 27 | 43 | 35 | 67 | 215 |
| Total hours | 1600 | 2476 | 3807 | 3447 | 3191 | 2774 | |
| Liters of gaseous oxygen utilized (calculated at 6 lit/min) | 5,76,000 | 8,91,360 | 13,70,520 | 12,40,920 | 11,48,760 | 9,98,640 | |

Intensive Care Unit has the maximum ventilator hours of 12035 (i.e 70%) followed by Post-Operative Ward. During the study period, month of July has 3807 ventilator hours (i.e 22%) which is the maximum

**4.1.2 Table 2:** General anaesthesia hours in operation theatre and Litres of gaseous oxygen utilized

| S. No | Month / Year | GA Hours | Litres of gaseous oxygen utilized (calculated at 6 lit/min) |
|---|---|---|---|
| 1. | May 2015 | 274 hours | 98,640 |
| 2. | June 2015 | 259 hours | 93,240 |
| 3. | July 2015 | 264 hours | 95,040 |
| 4. | August 2015 | 203 hours | 73,080 |

| | | | |
|---|---|---|---|
| 5. | September 2015 | 291 hours | 1,04,760 |
| 6. | October 2015 | 191 hours | 68,760 |

It shows utilization of gaseous oxygen in Operation Theatre is maximum in the month of September i.e 1,04,760 litres (20%) and least in the month of October.

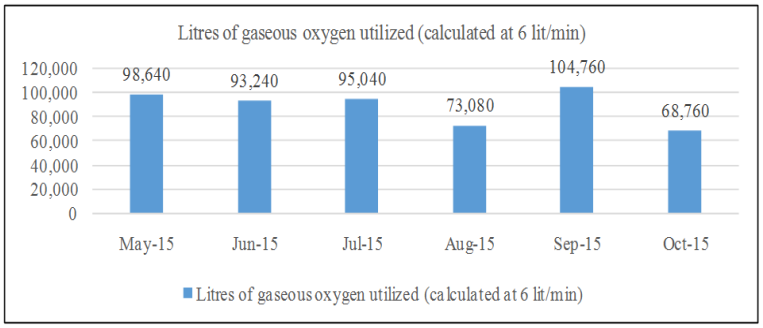


**Figure1:** litres of gaseous oxygen utilized in Operation theatre

**4.1.3 Table 3:** Number of litres of gaseous oxygen directly utilized through mask/nasal catheter in critical care areas

| Area | May 2015 | June 2015 | July 2015 | August 2015 | September 2015 | October 2015 | Total (litres) |
|---|---|---|---|---|---|---|---|
| PICU | 48,230 | 33,630 | 26,460 | 95,280 | 1,26,540 | 1,40,460 | 4,70,600 |
| ICU | 3,88,800 | 3,67,080 | 2,67,490 | 4,41,420 | 2,59,920 | 5,46,480 | 22,71,190 |
| NICU I | 74,880 | 19,440 | 61,680 | 40,560 | 78,240 | 39,600 | 3,14,400 |
| NICU II | 21,120 | 13,920 | 18,480 | 9,480 | 42,600 | 50,040 | 1,55,640 |
| RICU | 5,43,840 | 4,27,860 | 3,47,460 | 2,05,440 | 4,29,120 | 1,98,720 | 21,52,440 |
| Labour Room | 14,900 | 14,800 | 16,320 | 15,400 | 17,100 | 18,900 | 97,420 |
| EMD | 64,000 | 83,040 | 51,570 | 33,960 | 40,500 | 46,080 | 3,19,150 |
| POW | 1,61,520 | 1,18,320 | 1,43,760 | 1,63,360 | 1,01,220 | 1,03,260 | 7,91,440 |
| AMC | 2,80,800 | 1,13,040 | 1,84,680 | 83,520 | 5,07,600 | 3,90,600 | 15,60,240 |
| Total (litres) | 15,98,090 | 11,91,130 | 11,17,900 | 10,88,420 | 16,02,840 | 15,34,140 | |

It is seen that Intensive Care Unit with 22,71,190 litres (i.e 28%) has the maximum oxygen consumption followed by Respiratory Intensive Care Unit 21,52,440 litres (i.e 26%) and Acute Medical Care 15,60,240 litres(19%).

**4.2** Average oxygen consumption per patient per day is maximum in Intensive Care Unit 6801 litres followed by in Respiratory Intensive Care Unit 4815 litres

| Area | Total patient days |
|---|---|
| ICU | 971 |
| AMC | 1593 |
| POW | 3625 |
| EMD | 1053 |
| RICU | 443 |
| PICU | 877 |
| NICU I | 1213 |
| NICU II | 333 |
| Labour room | 2039 |

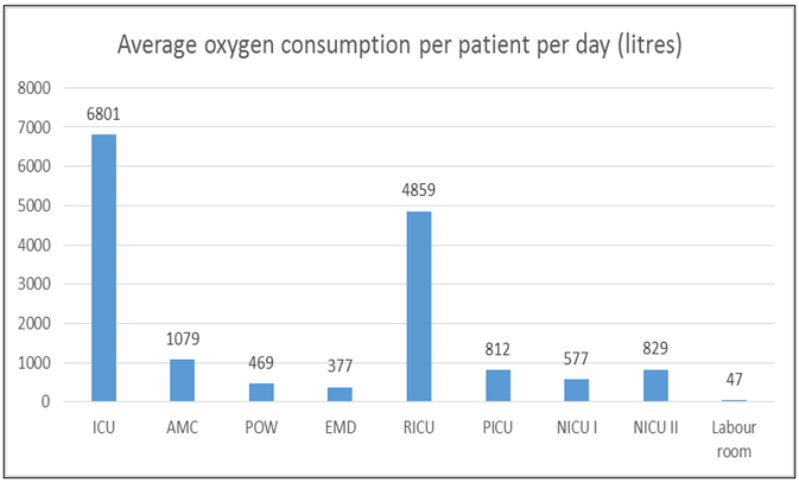

Table 4: total patient days in various areas Figure 2: Average consumption of oxygen per patient per day Average consumption of oxygen per patient per day in critical care areas has been calculated by dividing the litres of oxygen consumed during the study period by patient days in the study period.

4.3 Percentage of oxygen consumption per patient per day in various critical care areas

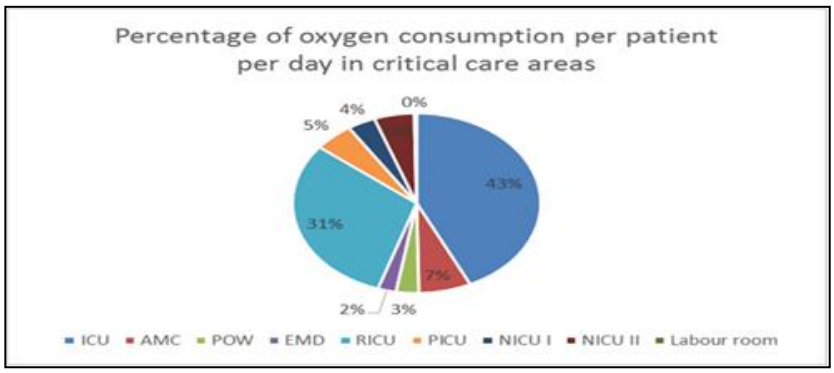


**Figure 3:** Percentage of oxygen consumption per patient per day in critical care areas

**4.4 Summary of utilization of oxygen**

**Table 5:** Utilization of gaseous oxygen in litres from May to October 2015

| Areas | May 2015 | June 2015 | July 2015 | August 2015 | September 2015 | October 2015 | Total (litres) |
|---|---|---|---|---|---|---|---|
| Ventilators | 5,76,000 | 8,91,360 | 13,70,520 | 12,40,920 | 11,48,760 | 9,98,640 | 62,26,200 (42%) |
| Operation theatre (GA) | 98,640 | 93,240 | 95,040 | 73,080 | 1,04,760 | 68,760 | 5,33,520 (3%) |
| various critical care | 15,98,090 | 11,91,130 | 11,17,900 | 10,88,420 | 16,02,840 | 15,34,140 | 81,32,520 (55%) |
| Total | 22,72,730 | 21,75,730 | 25,83,460 | 24,02,420 | 28,56,360 | 26,01,540 | |

It shows that maximum oxygen utilization is in the month of September 28,56,360 litres (i.e 19%) followed by October and July.

Direct oxygen utilization through masks and nasal catheters in critical care areas constitute 55% of oxygen utilization, ventilators in critical care units constitute 42% and total utilization in critical areas was 97% oxygen utilization in operation theatres constitute 3% of the total oxygen utilization.

Number of major surgeries were also found to be maximum in the month of September followed by July and October. Minor surgeries were maximum in the month of July followed by October and May.

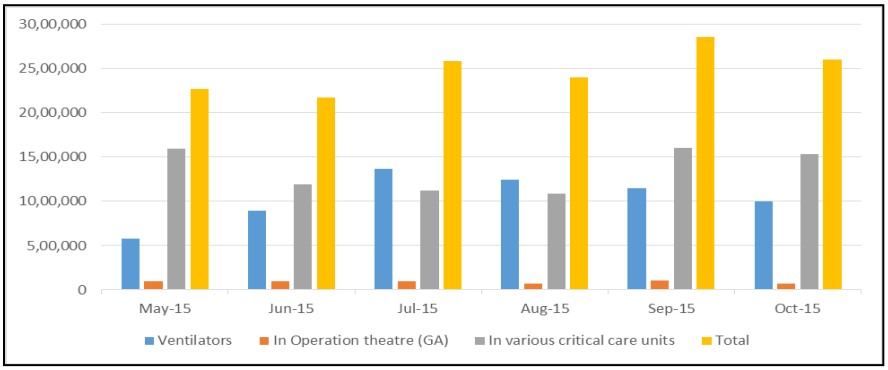


**Figure 4 :** Utilization of gaseous oxygen in litres from May to October 2015

**4.5 Costing of oxygen**

**Expenditure on oxygen has been studied under the following headings:**

- Expenditure on liquid oxygen
- Expenditure on oxygen cylinders (bulk and B type)

### 4.5.1 Expenditure on liquid oxygen during the study period

**Table 6:** Expenditure on Liquid Oxygen

| Month / Year | Liquid oxygen in Kgs purchased | Litres of gaseous oxygen (1kg = 699.6 litres of gaseous oxygen) | Cost including facility charges (Rupees) |
|---|---|---|---|
| May 2015 | 11,960 kgs | 83,67,216 | 1,77,639 |
| June 2015 | 13,150 kgs | 91,99,740 | 1,91,208 |
| July 2015 | 14,460 kgs | 1,01,16,216 | 2,11,900 |
| August 2015 | 11,180 kgs | 78,21,528 | 1,66,952 |
| September 2015 | 16,460 kgs | 1,15,15,416 | 2,36,569 |
| October 2015 | 13,850 kgs | 96,89,460 | 2,03,542 |

From the table 5 it is evident that maximum on Liquid Oxygen was purchased is in the month of September and expenditure was 2,36,569 Rs followed by July and October.

### 4.5.2 Expenditure on oxygen cylinders (bulk and B type)

**Table 7:** Expenditure on oxygen cylinders both bulk and B type

| | May 2015 | June 2015 | July 2015 | August 2015 | September 2015 | October 2015 | Total |
|---|---|---|---|---|---|---|---|
| Number of B type cylinders | 42 | 30 | 45 | 44 | 66 | 34 | 261 |
| Number of bulk cylinders | 1 | 1 | 1 | 7 | - | - | 10 |
| Cost of B type cylinders (Rs. 24.9 per cylinder) | 1045.8 | 747 | 1120.5 | 1095.6 | 1643.4 | 846.6 | 6498.9 |
| Cost of bulk cylinder (Rs. 116.2 per cylinder) | 116.2 | 116.2 | 116.2 | 813.4 | - | - | 1162 |
| Total cost of both cylinders (in rupees) | 1162 | 863.2 | 1236.7 | 1909 | 1643.4 | 846.6 | 7660.9 |

Expenditure on oxygen cylinders both bulk and B type was studied and maximum expenditure on oxygen cylinders was in the month of August 1909 Rs (i.e 25%) followed by September and July.

### 4.5.3 Total expenditure on oxygen during the study period

**Table 8:** Total expenditure on oxygen including cylinders and liquid oxygen from May to October 2015

| Month / Year | Expenditure on liquid oxygen (rupees) | Expenditure on cylinders (rupees) | Total cost (rupees) |
|---|---|---|---|
| May 2015 | 1,77,639 | 1162 | 1,78,801 |
| June 2015 | 1,91,208 | 863.2 | 1,92,071 |
| July 2015 | 2,11,900 | 1236.7 | 2,13,137 |
| August 2015 | 1,66,952 | 1909 | 1,68,861 |
| September 2015 | 2,36,569 | 1643.4 | 2,38,212 |
| October 2015 | 2,03,542 | 846.6 | 2,04,389 |
| Total | 11,87,810 | 7,661 | 11,95,471 |

Total expenditure on oxygen for the six months period studied is Rs. 11, 95,471. It is maximum in the month of September Rs 2,38,212 (i.e 20%) followed by July and October.

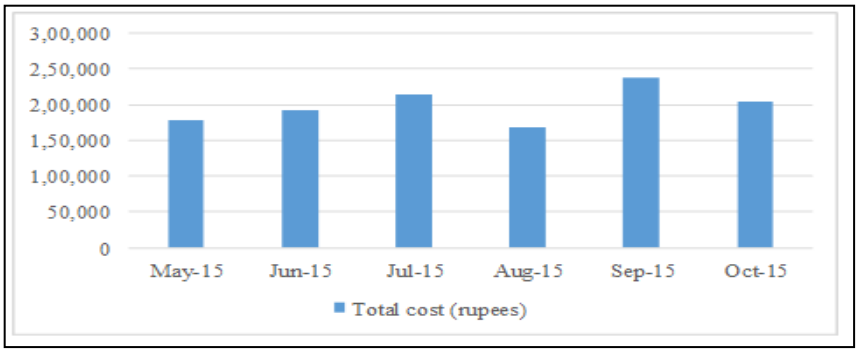


**Figure 5:** Total expenditure on oxygen including cylinders and liquid oxygen from May to October 2015

### 4.5.4 Estimation of cost of oxygen per patient per day in critical care area

By apportioning the 97% of total expenditure that is Rs. 11,59,606.87 to the percentage of oxygen consumption per patient per day in critical care areas, cost of oxygen for six months and cost of oxygen per patient per day in critical care areas is calculated.

**Table 9:** Cost of oxygen per patient per day in critical care areas

| S. No | Area | Cost of oxygen for six months in critical care areas (Rupees) | Cost of oxygen per patient per day (Rupees) |
|---|---|---|---|
| 1. | ICU | 497571.34 | 2704.19 |
| 2. | AMC | 78953.26 | 429.09 |
| 3. | POW | 34335.4 | 186.6 |
| 4. | EMD | 27582.68 | 149.9 |
| 5. | RICU | 355519.5 | 1932.17 |
| 6. | PICU | 59471.87 | 323.21 |
| 7. | NICU I | 42309.69 | 229.94 |
| 8. | NICU II | 60399.55 | 328.25 |
| 9. | Labour room | 3462.85 | 18.81 |
| | **Total** | **1159606.14** | **6302.16** |

Average cost of oxygen per patient per day is highest in ICU at Rs. 2704.19 followed by RICU at Rs. 1932.17

## V. Discussion

### 5.1 Utilization of oxygen

Oxygen treatment has been a cornerstone of acute medical care for numerous pathological states. Initially, this was supported by the assumed need to avoid hypoxemia and tissue hypoxia.[10]The current balance of clinical teaching emphasizes the avoidance of hypoxemia over concerns about the possible harm associated with hyperoxia. This would seem to be a well-founded thesis when considering the necessity of maintaining adequate oxygen delivery to cells to avoid cellular and organ dysfunction.[11] In our study it is observed that Ventilators in critical care units constitute 55% of oxygen consumption, direct oxygen consumption in critical care areas is 42% and oxygen consumption in operation theatres constitute 3% of the total oxygen consumption. It is seen that average oxygen consumption per patient per day is maximum in Intensive Care Unit (43%) followed by in Respiratory Intensive Care Unit (31%).

Intensive Care Unit has the maximum ventilator hours (70%) followed by Post-Operative Ward (15%). It is seen that Intensive Care Unit (28%) and Respiratory Intensive Care Unit (26%) have the maximum oxygen consumption followed by Acute Medical Care (19%).

Utilization of gaseous oxygen in Operation Theatre is maximum in the month of September (20%) and least in the month of October (13%). On elucidation, it was found that number of admissions and number of major surgeries within the study period was comparatively higher in the month of September followed by July and October.

### 5.2 Costing of oxygen

Medical gas administration is most common therapy given to cardio pulmonary cases. Amount spent by patients on it is tremendously increasing. In an era where oxygen generators are being installed in every healthcare set up an attempt was made to analyze the amount spent for 6 months on traditional liquid oxygen and cylinders ordering from Praxair. Total expenditure on oxygen for the six months period studied is Rs. 11, 95,471. It is maximum in the month of September Rs 2,38,212 (i.e 20%) followed by July and October.

During the study period 3% of oxygen is utilized in operation theatres and rest 97% is utilized in various critical care areas though ventilators, masks and nasal catheters. By apportioning 3% of the total expenditure on oxygen to Operation theatre, the amount spent for oxygen in operation theatre for six months worked out to be Rs.35,864.13 and thus, Rs. 194.91 per day. By apportioning the remaining 97% that is Rs. 11,59,606.87 to the percentage of oxygen consumption per patient per day in critical care areas, cost of oxygen for six months and cost of oxygen per patient per day in critical care areas is calculated. Average cost of oxygen per patient per day is highest in ICU at Rs. 2704.19 followed by RICU at Rs. 1932.17

## VI. Conclusion

Centralized oxygen is an essential patient care requirement in any hospital. It was concluded that intensive care unit is the area with maximum average oxygen consumption (43%) followed by respiratory intensive care unit (31%). Expenditure on oxygen corresponded with the utilization pattern for the months studied. Hence, it is imperative to have an effective centralized oxygen system, functioning round the clock without any disruption.

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