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Article

Effectiveness of Intermediate Respiratory Care Units as An Alternative to Intensive Care Units During The Covid-19 Pandemic in Catalonia

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Abstract: Objetives: During the COVID-19 pandemic, the risk of collapse of the health system created great difficulties. We will demonstrate that Intermediate Respiratory Care Units (IRCU) provide adequate management of patients with non-invasive respiratory support, which is particularly important in patients with SARS-CoV-2 pneumonia. **Methods:** A prospective observational study of patients with COVID-19 admitted to the ICU of a tertiary hospital. Sociodemographic data, comorbidities, pharmacological, respiratory support, laboratory and blood gas variables were collected. The overall cost of the unit was subsequently analyzed. **Results:** 991 patients were admitted, 56 to the IRCU (of the 81 a critical care unit). Mean age was 65 years (SD 12.8), Barthel Index 75 (SD 8.3), Charlson 3.1 (SD 2.2), HTN 27%, COPD 89% and obesity 24%. Significant relationship ($p < 0.05$) with higher mortality of the following: fever greater than or equal to 39ºC [OR 5.6; 95% CI (1.2-2.7); p = 0.020], protocolized pharmacological treatment [OR 0.3; 95% CI (0.1-0.9); p = 0.023] and IOI [OR 3.7; 95% CI (1.1-12.3); p = 0.025]. NIMV showed less of a negative impact [OR 1.8; 95% CI (0.4-8.4); p = 0.423] than IOI. The total cost of the IRCUs amounted to €66,233. The cost per day of stay in the IRCU was €164 per patient. The total cost avoided was €214,865. **Conclusion:** The pandemic has highlighted the importance of IRCUs in facilitating the management of a high patient volume. The treatment carried out in IRCUs is effective and efficient, reducing both admissions to and stays in the ICU.

Keywords: respiratory care; covid; ICU; cost-effectiveness

1. Introduction

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In March 2020, the SARS-CoV-2[1] pandemic was declared in Spain. From 25 February to 28 April 2020, a total of 203,715 cases were confirmed, of which 105,743 were older than 60 years; of these, 15,115 died, and 4,353 (4.12%) required admission to the intensive care unit (ICU)[2-6].

The number of ICU beds in Spain is lower than in neighbouring countries (approximately 3,600, equivalent to a ratio of 7.7 beds per 100,000 inhabitants, compared to 29.2/100,000 in Germany)[7-10], and the pandemic exposed the scarcity of this resource. The risk of the health system collapsing, especially in the initial phases of the pandemic, created major difficulties in the allocation of care resources and sparked a broad ethical debate.

Although the majority of people with COVID-19 develop mild symptoms or few complications, approximately 14% develop a serious illness which requires hospitalization, and 5% require admission to an ICU[9]. To facilitate difficult decision-making in ICUs during the COVID-19 pandemic, an ethical consensus was created[11,12]. This contains profiles of admission and location priorities in which semicritical units and/or intermediate respiratory care units (IRCUs) play a leading role.

An IRCU is defined as an area for monitoring and providing assistance to patients with acute respiratory failure who require non-invasive mechanical ventilation (NIMV)[13] and/or high-flow oxygen therapy (HFOT) as part of their treatment. Therefore, IRCUs can be a good alternative to an ICU in the treatment of patients admitted for COVID-19[14-17] who do not require imminent orotracheal intubation (IOI) or are in experiencing clinical improvement.

The implementation of IRCUs is not yet universal in our health system, with a consequent increase in health care expenditure and limitations in the use of adequate resources in each case[18-21].

IRCUs allow for an adequate selection of subsidiary patients who would benefit from invasive mechanical ventilation (IMV)[14,15], while also treating patients of more advanced age and/or with associated frailty. This characteristic has

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become more evident in patients with SARS-CoV-2 pneumonia in need of respiratory support[16,17]. Considerable[18-21] economic savings have been described in these units.

In this context, our study aims to describe the efficiency of an IRCU at a tertiary hospital, as well as the epidemiological and clinical characteristics and mortality of patients hospitalized in said unit.

2. Methods

This is a prospective observational study of patients with COVID-19 admitted to the IRCU of a tertiary university hospital during the first wave of the pandemic (from 25 February to 28 April 2020). Ethical approval was obtained from the Ethics and Research Committee.

The University Hospital in Barcelona has 295 general ward beds, 10 ICU beds and six IRCU beds. The IRCU is part of the Pulmonology Service and specializes in non-invasive respiratory support (NIRS) and postsurgical recovery from thoracic surgery. It is equipped with a maximum of six individual bays and continuous non-invasive monitoring, ventilators for NIMV (telemetered) and HFOT. The respirators available are V60 and Trilogy 200 Phillips Respironics®. During the first wave of the pandemic, a maximum of 11 bays were made available with these devices.

During the pandemic the manner in which personnel were assigned was modified. Day care was 12 hours long with pulmonologists in charge. Continuous night care was provided by intensive care physicians at the centre. Staffing in terms of nurses and assistants with experience in non-invasive respiratory support techniques consisted of two nursing graduates and two nursing care technicians. The unit received support from the rehabilitation service in the form of physiotherapy.

All cases of SARS-COV-2 pneumonia confirmed by Real time polymerase chain reaction (RT-PCR) for SARS-CoV-2 admitted to the IRCU were consecutively included. The group of patients included all patients with NIRS needs

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(experiencing clinical deterioration and possibly requiring admission to the ICU, those making a recovery, discharges from the ICU, and patients who had reached a therapeutic ceiling).

Analysis the sociodemographic variables (age, gender), clinical variables (Barthel Index, Charlson Comorbidity Index) and chronic and acute comorbidity, obesity and arterial hypertension were collected in addition to home respiratory therapeutic requirements prior to admission and at the time of discharge (NIMV, continuous positive airway pressure (CPAP) and home oxygen therapy); variables of the care process (average length of stay and hospital stay, diagnosis at admission, discharge status), as well as analytical and microbiological parameters, treatments during admission, destination on admission (ICU, IRCU or general ward) and support needs during their stay (NIMV, IMV and IOI, HFOT or CPAP). The costs derived per day of stay were estimated and compared with the costs of an ICU stay. To evaluate the efficiency of the unit, the days of admission to the ICU avoided were considered: patients assessed and taken on by the IRCU at the time of requiring NIRS, as well as post-ICU patients who were discharged early from the unit. The number of stays of patients admitted to the unit was calculated and the theoretical bed cost estimated for the ICU was calculated according to Section 1 of the Spanish Ministry of Health's classification[20]. The difference between the real cost calculated for the IRCU and the estimated cost for the ICU was considered to be the cost avoided.

The variables were described and compared according to their nature and distribution. A descriptive statistical analysis was performed for all variables and inferential statistics according to nature and normality, setting $p < 0.05$ as the limit of statistical significance. SPSS version 15 was used for the analysis.

3. Results

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A total of 991 confirmed COVID-19 patients were admitted during the study period. Eighty-one patients required admission to a critical care unit (IRCU or ICU) (8.2% of the total). Of these, (after passing through the Emergency Department), 24 patients (29.6%) were initially assigned to a general ward, 32 patients (39.5%) were assigned to the IRCU and 25 patients (30.8%) to the ICU.

After a mean period of 3.5 days (SD 1.8) following admission to a general ward, the condition of 16 of the 24 patients originally admitted (66.7%) worsened, requiring admission to the IRCU, while the remaining six patients were admitted to the ICU. Of the patients admitted to a critical care unit, 56 were admitted to the IRCU (69.13%). Only six of these patients needed to be transferred to the ICU due to clinical deterioration (10.9%). Patient flow is outlined in Figure 1.

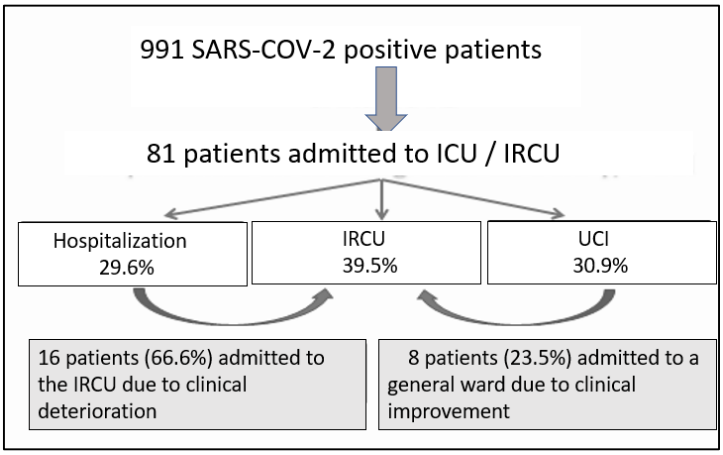

Figure 1. Patient Flow.

The patients admitted to IRCU had a mean age of 65 years (SD 12.8), a Barthel Index of 75 (SD 8.3), a Charlson Comorbidity Index of 3.1 (SD 2.2) and the following comorbidities: arterial hypertension accounted for 27%, chronic obstructive pulmonary disease (COPD) was found in 89% of patients, and obesity was found in 24% of patients.

Treatment was sought due to cough and/or dyspnoea and/or fever greater than or equal to 39ºC in 65.3% of the cases, with an evolution of 7.1 days (SD 4.0), while 76.4% presented with bilateral infiltrates according to a chest X-ray performed on admission.

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Upon admission to the IRCU, patients had a Sequential Organ Failure Assessment (SOFA) score of 4.5 (SD 2.2), a respiratory frequency (RR) of 23.1 rpm (SD 5.2) and a ratio of arterial oxygen pressure and fraction inspired oxygen (PaFiO2) of 136.2 (SD 65.1). In the initial arterial blood gas analysis, we obtained mean values on admission of pH 7.43 (SD 0.09), PaO2 67.5 mmHg (SD 37.5) and PaCO2 39.7 mmHg (SD 9.1).

The description of pharmacological treatment was governed by the protocol in force at our centre at all times. A total of 68.1% of patients received hydroxychloroquine (100 mg/day), lopinavir/ritonavir (200/50 mg/day) and azithromycin (500 mg/day). In 9.7% of the cases, boluses of corticosteroids (250 mg/day) were administered, 44.4% were administered corticosteroids at 1 mg/kg of weight/day and 6.9% were administered tocilizumab (600 mg in a single dose). 41.7% of the patients received anticoagulation therapy (1 mg/kg/12 hours of enoxaparin or equivalent) due to a high clinical suspicion of a thromboembolic event.

he NIRS which patients received upon admission to the IRCU consisted of oxygen therapy through nasal cannula and/or Venturi mask (69 patients, 85.2% of the total), NIMV (11 patients, 13.6%), CPAP (two patients, 2.5%), high-flow nasal cannulas (HFNC) (24 patients, 29.6%) and IOI (39 patients, 48.1%). Prone positioning was performed on 48 patients (59.3% of the total).

Patients on a Venturi mask received an average flow of 12.13 litres per minute (lpm) with an SD of 6.7 lpm, while those on a HFNC received an average flow of 30.96 lpm (SD 12.6 lpm) and 69.50% FIO2 (SD 19. 8%). Four simultaneous HFNCs were the only option available.

In those patients who received support with NIMV, the mean pressures used were inspiratory positive airway pressures (IPAP) of 17.64 +/- 3.91 cmH2O, reaching maximums of 25 CmH2O, and expiratory positive airway pressures (EPAP), with a mean of 9.27 +/- 2.24 cmH2O. NIMVs were used for an average of 4.45 days (SD 4.76 days).

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The mortality rate of the 81 patients admitted to the critical care unit was 25%. PaFiO2 at admission, PaO2, heart rate, RR, levels of lactate dehydrogenase (LDH), potassium, alanine aminotransferase (ALT) and total bilirubin were significantly associated with higher mortality in a univariate analysis (Table 1).

A significant relationship ($p < 0.05$) was found with higher mortality in patients with fever greater than or equal to 39ºC [OR 5.6; 95% CI (1.2-2.7); p = 0.020] at the time of admission and with the use of protocolized pharmacological treatment [OR 0.3; 95% CI (0.1-0.9); p = 0.023] (hydroxychloroquine, lopinavir/ritonavir and azithromycin) and the IOI [OR 3.7; 95% CI (1.1-12.3); p = 0.025]. Treatment with intravenous corticosteroids was close to statistical significance for the reduction of mortality [OR 0.3; 95% CI (0.1-1.1); p = 0.0508]. The use of NIMV, though without statistical significance, showed a less negative impact [OR 1.8; 95% CI (0.4-8.4); p = 0.423] than IOI (figure 2).

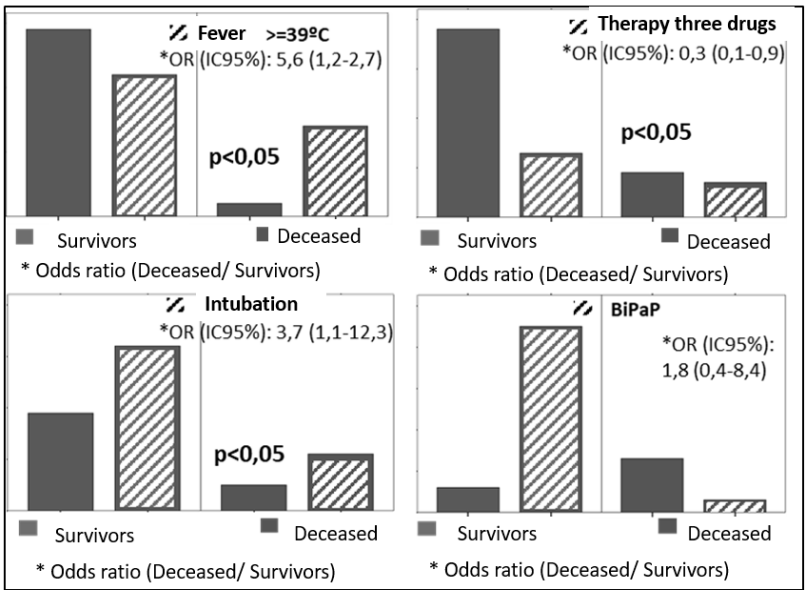

Figure 2. Representation of significant associations of qualitative variables with mortality.

Description of the cost avoided based on the total cost of the unit. A calculation of the hospitalization costs of the IRCU was performed on a total of 56 patients over a period of two months, based on the rates detailed in a study carried out at our centre prior to the COVID-19 pandemic[21].

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The total number of stays amounts to 403.2, with an average of 7.2 days of admission (range 3.8-11 days), and expenses are broken down into the following items:

Personnel costs taking into account the totality of the existing workforce during all work shifts and the current salary agreement: €52,020.

Expenses for the consumption of sanitary material, instruments, clothing, and linen, among others: €5,272.

Amortization and equipment: Most of the material used in the unit had been purchased more than four years earlier, while the remaining material was on loan. No new equipment had been purchased. The equipment inventoried in the unit (not on loan) has a purchase cost of €17,795. None of these expenses is reflected in the period of time that under study.

Testing and radiology: This has been calculated based on current care protocols rather than being detailed by patient. Three tests were performed as per protocol during a patient's stay (on admission, at 48 hours and at 6-7 days); X-rays were performed on admission and at 48 hours. Red blood cell and platelet transfusions were taken into account. Therefore, the cost amounts to €3,816.

Pharmacy: An exhaustive comparison was carried out between the drugs prescribed in the IRCU and those prescribed in the ICU during the period studied. A dispensing cost was obtained per patient during their stay in the IRCU, according to the price of each product and a comparison of expenses with respect to the ICU was performed. In the IRCU, the average pharmaceutical cost per patient and stay was €91.51 (SD €221.73), compared to €163.83 in the ICU (SD €150). Figure 3 shows that the average expenditure in the IRCU is higher than in the ICU; nevertheless, since fewer patients were admitted to the IRCU, the figure is based on a smaller dataset. There were no significant differences between the average cost of dispensing a drug in the ICU and in the IRCU.

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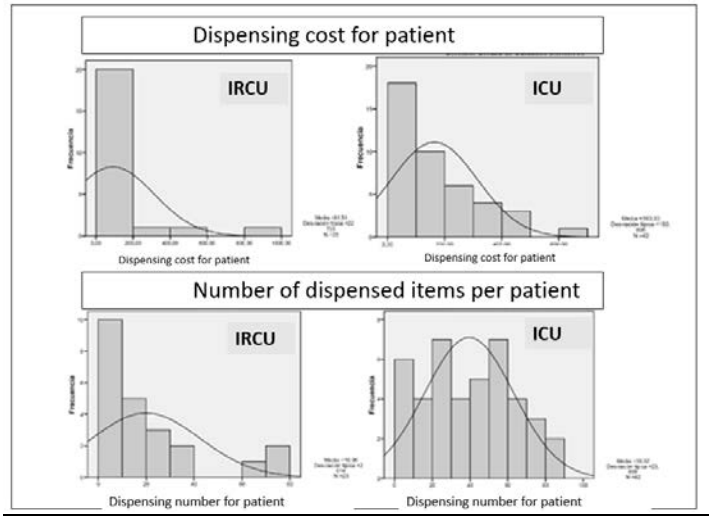

Figure 3. Comparison of pharmacological dispensing cost and number of dispensations per patient between the Intermediate Respiratory Care Unit (IRCU) and the Intensive Care Unit (ICU).

The total pharmacy expenditure amounts to €5,124 (some €3,713 more than the previous total of €8,468 during the pre-pandemic period according to a recent study[22]).

The total cost of the IRCU in the study period, as a result of the sum of the categories described above, amounted to €66,233. Taking into account the 403.2 days of stay during this period, the cost per day in the IRCU amounts to €164 per day per patient.

The IRCU saved the hospital a cost equivalent to 403.2 patient days, with a theoretical value of €281,098, with respect to the ICU according to Section 1 of the Spanish Ministry of Health's classification. The difference between the actual cost calculated for the IRCU and the estimated cost for the ICU was considered to be the cost avoided. Therefore, taking on the IRCU's own cost, the actual cost avoided during these two months of the pandemic is €214,865 for the total of 56 patients. Table 2.

4. Discussion

During the pandemic, the number of ICU beds was insufficient given the increase in demand, a situation for which the health system was not fully prepared. Several studies and protocols outline the possible scenarios in which it would be necessary to increase the number of ICU[18,19] beds. However, little was published during the first wave of the pandemic

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with regard to NIRS and the need for an intermediary step before reaching the ICU. The IRCU has been working to avoid IOI and/or to assist in early extubations.

During the period analysed, the IRCU was essential for the organisation of both our patients and the hospital. Note that 40% of our patients with COVID-19 were admitted directly to the IRCU. This percentage is higher than those who were initially admitted to a general ward or the ICU, and this figure increases to practically 70% of those infected by SARS-CoV-2 when we assess the total number of patients who required IRCU services at some time during their hospitalization. In this way, the IRCU offered support to the ICU (and to the general ward) at a time when admission criteria played a fundamental role.

Heili-Frades et al.[20] state that this type of unit represents a very important added economic saving in terms of avoided expenses. An IRCU offers assistance to patients of a high complexity, whose main axis of treatment is NIMV, IMV by tracheostomy or HFOT. The cost avoided occurs because this type of unit avoids prolonged or unnecessary stays in the ICU and provides support to those patients whose therapeutic ceiling is NIRS. If there no resources had been available in the ICU, some of these patients would have been treated in a general ward.

In our study, we performed an analysis of the overall consumption of the unit. The unit's pharmacy cost has also allowed us to make a comparison with that of the ICU, showing it to be lower overall in the IRCU than in the ICU. We reached the conclusion that the cost of an IRCU bed in our centre during the period under study amounts to slightly less than €200 per day. However, the concept of avoided cost should not be considered solely from an economic point of view, the added value of the potential improvement to ICU admission capacity should also be considered, together with what this implies for the organization of highly complex medical and surgical activity, which supposes an additional benefit.

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The results of this study suggest that patients do not present with a large number of comorbidities. Most patients consulted one week after the onset of symptoms, and at the time of admission to the unit, they had already developed bilateral pneumonia. They were experiencing significant respiratory failure, a fact which led to a pressing need for NIRS.

The values associated with a worse prognosis are mainly onset with high fever and greater gasometric involvement, regardless of age, gender, previous functional status or the presence of comorbidities. A beneficial trend of treatment with corticosteroids (1 mg/kg) and a worse prognosis associated with IOI was observed. NIMV could be proposed as an alternative in some cases, since the use of non-invasive mechanical ventilation, even without statistical significance, showed a less negative impact than IOI.

Invasive measures such as IMV provide benefits but also drawbacks or deleterious effects. It is essential to determine the exact location of patients and avoid ICU stays for those who do not benefit from their stay[14,15]. Therefore, their levels of care have been described: up to 40% of patients admitted to an ICU do not require intubation, and only 40% of cases of acute respiratory failure require IMV[13], which could alert us to issues of inadequate resource management.

Reports on hospitalizations due to SARS-CoV-2 pneumonia usually refer to admissions to the ICU, while the number admitted to the IRCU is often ignored. Nonetheless, these units have been shown to be effective and efficient given their high degree of specialization. This study looks at the key role played by the IRCUs during the start of the pandemic in Catalonia.

In conclusion, the COVID-19 pandemic has highlighted the importance of this type of unit in hospitals since they facilitate the management of a high volume of patients with severe respiratory failure and high dependence. In our study, the treatment performed was effective and efficient, reducing both admissions and stays in the ICU.

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Authors contributions:

All authors reviewed the final manuscript

- Marina Galdeano Lozano: Conceived the study and the analysis. Performed the analysis. Coordination. Description of tables and figures. Literature search. Wrote the paper. Reviewed the paper. Translated the paper.
- Julio César Alfaro Álvarez: Conceived the study and the analysis. Literature search Performed the analysis. Reviewed the paper. Translated the paper.
- Núria Parra Macías: Performed the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Rosario Salas Campos Performed the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Sarah Heili Frades: Conceived the study and the analysis, Performed the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Francesc López Seguí: Performed the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Josep Maria Montserrat: Conceived the study and the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Antoni Rosell Gratacós: Conceived the study and the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Jorge Abad Capa: Conceived the study and the analysis. Description of tables and figures. Wrote the paper. Reviewed the paper. Translated the paper.
- Olga Parra Ordaz: Conceived the study and the analysis. Performed the analysis. Reviewed the paper. Translated the paper.

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