

Cost Avoided by an Intermediate Respiratory Care Unit during the First Wave of the COVID-19 Pandemic

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Abstract

Introduction: During the COVID-19 pandemic, the risk of collapse of the health system generated great difficulties. UCRI allow adequate management of patients with non-invasive respiratory support, which is evident in patients with SARS-VOC-2 pneumonia.

Methods: A prospective observational study of patients with COVID 19 admitted to an ICU of a tertiary hospital from February 25 to April 28, 2020 with a staff of 11 beds. Sociodemographic, comorbidities, pharmacological, respiratory support, laboratory and blood gas variables were collected. The overall cost of the unit was analyzed.

Results: 991 patients were admitted, 56 to the ICU (of the 81 who needed admission to the critical care unit). Mean age of 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 regarding: fever greater than or equal to 39°C [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 the IOT [OR 3.7; 95% CI (1.1-12.3); $p=0.025$]. NIMV showed less negative impact [OR 1.8; 95% CI (0.4-8.4); $p=0.423$] than IOT. The total cost of UCRI amounted to 66,233 Eur. The cost per day of stay in UCRI was 164 Eur. The cost avoided was 214,865 Eur.

Conclusion: The pandemic has highlighted the importance of UCRI allowing the management of a high patient volume. The treatment carried out in them is effective and efficient, reducing both admissions and stays in the ICU.

Keywords: Intermediate Respiratory Care Unit (IRCUs) • SARS-COV2• Non-Invasive Respiratory Support (NIRS) • Non-Invasive Mechanical Ventilation (NIMV)

Introduction

In March 2020, the SARS-CoV-21 pandemic was declared in Spain. From February 25 to April 28, 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) [1-6].

The number of ICU beds in Spain is lower than that of other 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 revealed the scarcity of this resource. The risk of the health system collapsing, especially in the

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initial phases of the pandemic, generated great difficulties in the allocation of care resources and a broad ethical debate.

The majority of people with COVID-19 develop a mild or uncomplicated disease, approximately 14% develop a serious illness that requires hospitalization, and 5% require admission to an intensive care unit (ICU) [9]. To facilitate difficult decision-making in ICUs during the COVID-19 pandemic, an ethical consensus has been created [11,12]. In it, there are profiles of admission and location priorities, where the semicritical units and/or Intermediate Respiratory Care Units (IRCUs) have a leading role.

An IRCU is defined as an area of monitoring and 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 the ICU in the treatment of patients admitted for COVID-19 [13-16], that are without the need for imminent OTI or are in a situation of improvement.

The implementation of the IRCUs is not yet universal in our environment, with the consequent increase in health care expenditure and limitation in the use of adequate resources in each case [14-16].

The IRCUs allow an adequate selection of subsidiary patients to benefit from invasive mechanical ventilation (IMV)[14,15], also taking on patients of more advanced age and/or associated frailty. This characteristic has become more evident in patients with SARS-CoV-2 pneumonia in need of respiratory support [15]. Economic savings have been described in these units and can be very considerable [16].

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

Methods

Study design

This was a prospective observational study of patients with COVID-19 admitted to an IRCU of a tertiary university hospital during the first wave of the pandemic (from February 25 to April 28, 2020).

Characteristics of the centre

The Sagrat Cor University Hospital in Barcelona has 295 general ward beds, 10 ICU beds and 6 IRCU beds. This unit is dependent on the Pulmonology Service and specializes in Non Invasive Respiratory Support (NIRS) and postsurgical recovery from thoracic surgery. It is equipped with a maximum of 6 individual boxes and continuous noninvasive monitoring, ventilators for NIMV (telemetered) and HFOT. The respirators available are V60 and Trilogy 200 Phillips Respironics®. During the first wave, 11 boxes in total were made available in these devices.

In a pandemic situation, assigning of personnel was modified. Day care was of 12 hours with pulmonologists in charge. Continuous night care was provided by intensive care physicians at the centre. The number of nurses and assistants with experience in noninvasive respiratory support techniques was 2 nursing graduates and 2 nursing care technicians. The unit received support from the rehabilitation service through specific physiotherapy.

Patients

All cases of SARS-CoV-2 pneumonia confirmed by PCR admitted to the IRCU were consecutively included. The group of patients included all patients with NIRS needs (in a worsening situation and possibility of admission to the ICU, in a situation of improvement, discharges from the ICU, or patients who have reached therapeutic ceiling).

Analysis

Sociodemographic variables (age, gender), clinical variables (Barthel index, Charlson comorbidity index) and chronic and acute comorbidity, obesity and arterial hypertension (AHT) were collected; also 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 (days of average stay and hospital stay, diagnosis at admission, situation at discharge), as well as analytical and microbiological parameters, treatments during admission, location of admission (ICU, IRCU or general ward) and support needs during their stay (NIMV, IMV and orotracheal intubation (OTI), HFOT or CPAP). The costs derived per day of stay were estimated and compared with the costs of 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 allowed early discharge from that unit. The number of stays of patients admitted to the unit was calculated, and the theoretical bed cost estimated for Section 1 of the ICU was attributed, according to the classification of the Spanish Ministry of Health²⁰. The difference between the real cost calculated for the IRCU and the estimated cost for the ICU was considered 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.

Results

Sample characteristics

A total of 991 confirmed COVID-19 patients were admitted during the study period. Eighty-one patients required admission to a critical care unit (ICRU or ICU) (8.2% of the total). Of these, initially (after passing through the emergency department), 24 patients (29.6%)

went to the general ward, 32 patients (39.5%) to the IRCU and 25 patients (30.8%) to the ICU.

After a mean of 3.5 days (SD 1.8) of admission to the general ward, 16 of the 24 patients initially admitted (66.7%) worsened and required admission to the IRCU, and the other 6 were admitted to the ICU. Of the patients admitted to the critical care unit, 56 were admitted to the IRCU (69.13%). Only 6 of these patients required transfer to the ICU due to worsening (10.9%). The flow of patients is represented in Figure 1.

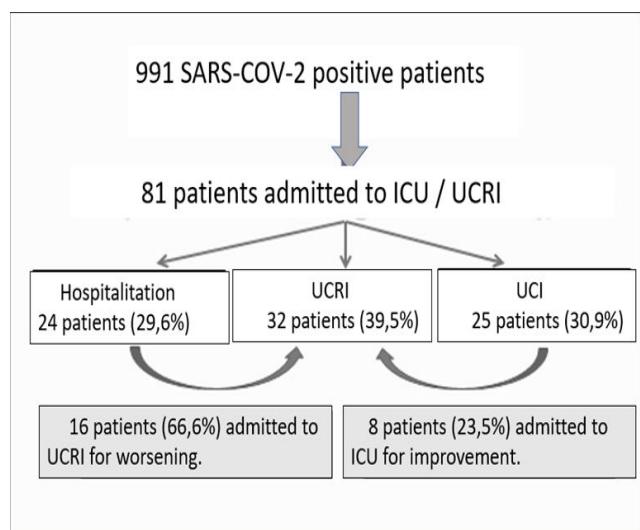


Figure 1. Flow of patients within the Intermediate Respiratory Care Unit (IRCU), admitted directly from the Emergency Department or from Hospitalization services due to worsening and from the Intensive Care Unit (ICU) due to patient improvement.

Description of patients admitted to IRCU

The patients had a mean age of 65 years (SD 12.8), a Barthel index of 75 (SD 8.3) and a Charlson comorbidity index of 3.1 (SD 2.2), and the comorbidities: AHT was 27%, chronic obstructive pulmonary disease (COPD) was found in 89% of patients, and obesity was found in 24% of patients.

The reasons for consultation were cough and/or dyspnoea and/or fever greater than or equal to 39°C in 65.3% of the cases, with an evolution of 7.1 days (SD 4.0) and 76.4% with bilateral infiltrates in the chest radiography at the time of admission.

Upon admission to the IRCU, there was a SOFA (Sequential Organ Failure Assessment) index of 4.5 points (SD 2.2), a respiratory

frequency (RR) of 23.1 rpm (SD 5.2) and a ratio of arterial oxygen pressure to fractional inspired oxygen (PaFiO₂) of 136.2 (SD 65.1). In the initial arterial blood gas analysis, we obtained mean values at admission pH 7.43 (SD 0.09), PaO₂ 67.5 mmHg (SD 37.5), and PaCO₂ 39.7 mmHg (SD 9.1).

Description of pharmacological treatment

Pharmacological treatment was governed by the protocol in force in 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 single dose). Anticoagulation was carried out (1 mg/kg/12 hours of enoxaparin or equivalent) in 41.7% of the patients due to high suspicion of a thromboembolic event.

Description of respiratory support

The NIRS that patients received upon admission to the IRCU was oxygen therapy through nasal cannula and/or Venturi mask (69 patients, 85.2% of the total), NIMV (11 patients, 13.6%), CPAP (2 patients, 2.5%), high-flow nasal cannulas (HFNC) (24 patients, 29.6%) and OTI (39 patients, 48.1%). Proning was performed in 48 patients (59.3% of the total).

The patients received, by means of a Venturi mask, an average flow of 12.13 litres per minute (lpm) with an SD of 6.7 lpm. By HFNC, the patients 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 cm H₂O, reaching maximums of 25 cm H₂O, and Expiratory Positive Airway Pressures (EPAP), with a mean of 9.27 ± 2.24 cm H₂O. The days of NIMV use were 4.45 days on average (SD 4.76 days).

Clinical evolution

The mortality of the 81 patients admitted to the critical care unit was 25%.

PaFiO₂ at admission, PaO₂, heart rate, RR, and levels of lactate dehydrogenase (LDH), potassium, alanine aminotransferase (AST) and total bilirubin were significantly associated with higher mortality in a univariate analysis (Table 1).

Table 1. Clinical variables and tests associated with mortality.

Tests variables	Deceased	Alive	p
LDH (mean [SD])	649 UI/L [649.7]	327 UI/L [327.0]	0.002
K ⁺ (mean [SD])	3.8 mEq/l [0.58]	4.5 mEq/l [0.65]	0.025

ALT (mean (SD))	81.8 UI/L [63.0]	38.6 UI/L [15.47]	0.004
Total bilirubin (mean [SD])	1.3 mg/dL [0.79]	0.6 mg/dL [0.48]	0.009
Arterial blood gas analysis	Fallecidos	Vivos	p
PaO ₂ (mean [SD])	44.5 mmHg [25.3]	78.9 mmHg [34.4]	0.034
PaFiO ₂ (mean [SD])	89.7 [26.3]	147.2 [66.0]	0.002
Clinical variables	Fallecidos	Vivos	p
HR (mean [SD])	97.5 lpm [20.2]	84.2 lpm [17.187]	0.015
RR (mean [SD])	28.9 rpm [4.9]	24.4 rpm [6.1]	0.013

A significant relationship ($p <0.05$) was found with higher mortality in patients with fever greater than or equal to 39°C (OR 5.6; 95% CI (1.2-2.7); $p=0.020$) at the time of admission, 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 OTI (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, even without statistical significance, showed a less negative impact (OR 1.8; 95% CI (0.4-8.4); $p=0.423$) than OTI (Figure 2).

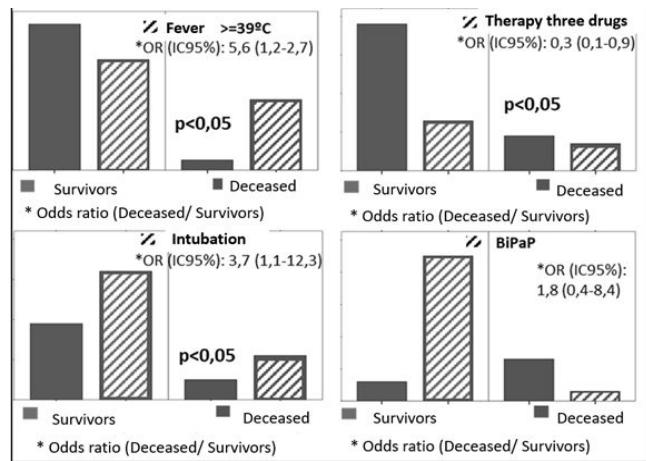


Figure 2. Representation of significative associations of qualitative variables with mortality.

Description of the cost avoided through the total cost of the unit

A calculation of the hospitalization costs of the IRCU was performed on a total of 56 patients during a period of 2 months, from the rates detailed in a study (in our centre) prior to the COVID-19 pandemic 21.

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 in all work shifts and the current agreement: € 52,020.

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

Amortizations and equipment: Most of the material of the unit has more than 4 years since purchased, and the rest is in a situation of transfer. No new equipment has been purchased. The equipment inventoried in the unit (not transferred) has a purchase cost of € 17,795. None of these expenses is reflected in the period of time that we are studying.

Testing and radiology: It has been counted based on current care protocols instead of detailed by patient. Three tests were performed per protocol during their stay (at admission, at 48 hours and at 6-7 days); X-rays were performed at 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 made between the drugs prescribed in the IRCU and those prescribed in the ICU during the dates studied. According to the price of each product, a dispensing cost was obtained per patient during their stay in the IRCU, 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 that in the ICU; even so, having fewer patients admitted to the IRCU than to the ICU makes the set lower. There were no significant differences between the average cost per dispensing of drugs in the ICU and in the IRCU.

The total pharmacy expenditure amounts to € 5,124 (€ 3,713 more than in a nonpandemic situation according to a previous study, where the annual pharmacy cost amounts to € 8,46,822).

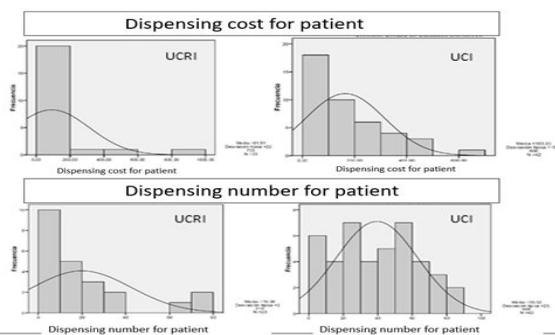


Figure 3. Comparison of pharmacological dispensing cost and number of dispensations per patient between the Intermediate Respiratory Care Unit (IRCU) and the Intensive Care Unit (ICU).

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

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

Table 2. Hospitalization costs of the IRCU on a total of 56 patients during a period of 2 months of pandemics.

Variables	(€)Cost
Personnel costs	52,020.95
Expenses for consumption	5,272.27
Amortizations and equipment	0
Testing and radiology	3,816
Pharmacy	5,124.56
Total cost of the IRCU	66,233.78
Cost avoided by the IRCU during these 2 months of pandemic for the total of 56 patients	214,865.16

Discussion

During the pandemic, ICU beds have been insufficient, requiring a large number of them, for which we were not prepared. Several studies and protocols indicate the possible scenarios in which it will be necessary to increase the number of ICU^{18,19} beds. However, little has been published during the first wave about NIRS and the need to have an intermediate point before reaching the ICU. The IRCU has been working to avoid OTI and/or to help in early extubations.

During the period analysed, the IRCU was essential for our patients and hospital's organization. Note that 40% of our patients with COVID-19 were directly admitted to the IRCU. This percentage is higher than those who were initially admitted to the general ward or the ICU, and the 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 et al. describe that this type of unit represents a very important added economic saving in terms of avoided expenses. An IRCU offers assistance to patients of 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 in which their therapeutic ceiling is NIRS. If there were no resources 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 pharmacy cost has also allowed us to make a comparison with that of the ICU, showing to be lower overall in the IRCU than in the ICU. We reached the conclusion that an IRCU bed in our centre during these days amounts to approximately less than 200 € per day. The concept of avoided cost should not be considered only from an economic approach, the added value of the potential improvement of the ICU admission capacity should be considered as well, with what this implies for the organization of high complexity medical and

surgical activity and which supposes an additional extra benefit.

The results of this study suggest that patients do not present large comorbidities. Most of them consulted one week after the onset of symptoms, and at the time of admission to the unit, they had already developed bilateral pneumonia. There is significant respiratory failure, a fact that leads to a high 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 OTI was observed. NIMV could be proposed as an alternative in some cases, so much so that the use of non-invasive mechanical ventilation, even and without statistical significance, showed less negative impact than OTI.

Invasive measures such as IMV have benefits but also drawbacks or deleterious effects. It is essential to determine the exact location of patients and avoid ICU stays in 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 IMV13, which could alert us about inadequate resource management.

Conclusion

The COVID-19 pandemic has highlighted the importance of this type of unit in hospital centres, allowing 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.

When reporting the number of patients with SARS-COV-2 pneumonia requiring admission to the ICU, the number of patients requiring IRCU is not indicated. It has been shown that these units are effective and efficient given their great specialization. In the case studied in this article, the important role it has played during the first months of the pandemic is described.

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