

IMPACT OF THE PNEUMONIA ZERO EDUCATIONAL PROGRAM IN THE RATES OF PNEUMONIA ASSOCIATED TO MECHANICAL VENTILATION

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Abstract: **Background:** Pneumonia associated with mechanical ventilation (VAP) is the main infection acquired in Intensive Care Services or Units (ICU) (CDC, ENVIN-HELICS 2010). Our country has a national survey called ENVIN, which allows us to establish surveillance regarding nosocomial infection in general and VAP. **Methods:** Retrospective observational study. ENVIN data: 01.04.2011 / 31.12.2019. 2020 and 2021 have been excluded because the conditions and characteristics of our unit have radically changed due to the pandemic situation. Statistical analysis was made treating dates with Poisson regression, Wald's confidence interval, and Wald chi square. The main part of this work was educational campaign, involving an amount of 126 people. It had presential and online phases. In the logistics part, Pharmacy Service prepared oral solution of chlorhexidine (2%). Then we decided to commitment and evaluate the implementation of 3 optional measures. In statistics hand, incidence density has been used as a measure of frequency, density represents pneumonia for every 1000 days of MV. Both, the NAVM rates and densities between the different years were analysed using the Rate Comparison Z Test. **Results:** Year of contrast 2011, 8.73/dMV (mechanical ventilation days). 2012 statistically significant, $p_value < 0.001$. 2013 NOT statistically significant, $p_value = 0.155$. 2014 statistically significant. 2015 statistically significant. 2016 0.144, NOT significant, 2019 statistically significant. The difference in 2018 is statistically significant compared to 2012 and 2014 (0.044 y 0.029 respectively). **Conclusions:** We have succeeded in implementing the protocol. Number of pneumonia has decreased.

Keywords: Mecanical ventilation pneumonia, intensive care, educational program, workteam.

INTRODUCTION

In 1994, the Infectious Diseases Working Group of the Spanish Society of Intensive Care, Critical Care and Coronary Units (GTEI-SEMICYUC) developed the National Survey of Nosocomial Infection Surveillance (ENVIN) as a computerized registry of the incidence of nosocomial infection for Services or Intensive Care Units (ICU)¹. It is a longitudinal incidence register that controls patients from the day of admission to the day of discharge (and assumes as acquired in the ICU the infections that are diagnosed in the next 48 h to discharge) collects all the infections acquired in ICU and is therefore more reliable and truthful than the information provided by prevalence studies (which occurs in one day).

The packs of measures applied to prevent ventilator associated pneumonia (VAP) were first included in the American campaign "The 100k lives campaign" although in this case the measures were chosen together with others aimed at preventing different complications in patients with VAP². In this study, a 59% reduction in the VAP rate was observed in those units that had met more than 95% of the proposed measures.³ Further studies were then published with the same or different packages of interventions^{4,5} and in all a decrease in the incidence of VAP has been demonstrated. In fact, even in China, there is a recent study that demonstrates the effectiveness of preventive measures in reducing the morbidity of these patients⁶.

VAP occurs within 48-72 hours of endotracheal intubation (or tracheotomy) and was not present, nor in the incubation period, at the time of intubation. This definition includes pneumonias diagnosed within 72 hours after extubation or withdrawal of the tracheostomy⁷.

Early NAVM, before the 5th day of hospitalization, has a better prognosis, usually produced by sensitive bacteria⁴.

Late NAVM, more than five days of hospitalization, are more likely to be produced by multiresistant germs (MDR) and are associated with higher morbidity and mortality⁷.

Infections associated with healthcare are mostly preventable errors. According to the Institute of Medicine estimates, up to 100,000 patients could die due to medical errors⁸. With the exception of emergencies, few services are as complex as the units that care for critical patients, and the possibility of incidents, errors, complications or as we want to name them during health care increases proportionally to the complexity of the environment. In 1995, a study determined that in the Intensive Care Units (ICU) of American university hospitals, up to 150,000 serious errors with life deterioration are annually produced and that, on a daily basis, one patient is exposed to 1.7 incidents⁹. In a study conducted in the ICUs of our country, 1.22 incidents were detected for each patient admitted and 5.89 incidents per 100 patients and hour¹⁰.

The purpose of this study was to demonstrate that the training we gave to our staff managed to significantly decrease the VAP, thus reducing morbidity and mortality and health expenditure. .

METHODS

- Retrospective observational study. Data of the complete ENVIN record: 01.04.2011 / 31.12.2019. Data for 2020 and 2021 have been excluded because the conditions and characteristics of our unit have radically changed due to the pandemic situation, multiplying the number of admissions and requiring the help of different specialists as well as the hiring of new staff without experience in critical care. However, we do have them. There is no data collected in 2017 because Granada underwent a change

in the health distribution, being unified the ICUs of the two hospitals that we have in our city. Before 2015, our ICU consisted of 2 parts: coronary and polyvalent patients. From the end of 2015 to beginning of 2018, it became a neurotraumatological ICU. In 2019 we resumed the 2 rooms: multipurpose and coronary. We kept 18 beds at all times. In 2020 we suffered COVID-19 pandemic, we had to transform ur unit in base to special circumstances, so we had to change our work teams, they were formed mainly by intensivists (14 adjuncts and 5 residents) and anesthetists, presenting a ratio doctor/patient 1/11. Patients have been treated in our facilities (coronary, COVID) and in Resuscitation (general and COVID). The nursing team and auxiliary personnel in first wave were ICU and Anesthesia and Resuscitation personnel with experience in critical patients and familiar with Zero programs. In the second wave was ICU staff and staff with little experience in patients Critics and Zero Programs. Our patients were multiplied for 4.

- Hospital of 682 beds, 18 beds of UCI.

Inclusion criteria were patients admitted more than 1 day in the Intensive Care Services. It is considered more than 1 day when the difference between the date of discharge minus the date of entry is greater than 24 hours. Patients excluded were those patients admitted prior to the study period and remaining admitted during the study phase.

Educational campaign consisted in three phases, a total of 137 people took part being nursing, nursing assistants, residents, specialists of our service and of Anesthesiology and Reanimation. "On line" phase had a training module of the Ministry of Health were they learn diagnosis, epidemiology, preventive measures and ítems of patient's safety. It had a duration of 10 hours. The second phase was

face-to-face course consisting in work shift practices with a duration of 7 hours. The last phase was evaluation “on line”: with diploma accredited to approved students issued by the Ministry of Health.

We started this program working with Pharmacy Service, they prepared an oral solution of chlorhexidine (2%) for oral cleaning. We request tracheotomy tubes and cannulae with subglottic aspiration, nozzles and active humidification systems. The we standardized intervention of a set of basic measures (compulsory compliance) and one of the specific measures (highly recommended): STOP VAP¹¹. We rely on the American campaign “The 100k lives campaign”, with a completion of more than 95% of the package of measures, showed a reduction of 59% the rate of NAV¹². The package of measures for reducing the NAV of Bermick (2006) achieved, in the first year, a reduction of 40%¹². This intervention involves the mandatory application of seven measures and the commitment to evaluate the implementation of three other optional measures related to the insertion and maintenance of mechanical ventilation equipment that have been shown to have a high degree of evidence in the review of the literature by a team of experts from SEMICYUC and SEEIUC. Specific measures are highly recommended but its applicability and tolerability is lower, so its recommendation for implementation is not required to comply with the participation in the project NZ in addition, some of them have not demonstrated the effectiveness to be obligatory as for example the selective digestive decontamination^{13,14}. In the last years, in the elaboration of protocols an original marketing concept has been incorporated, the use of bundles, that is, the simultaneous application of a series of evidence-based measures, which in their

joint application substantially improve the result of patients, which ensures that they do not stop receiving the best possible treatment¹⁵. We resume basic and optional measures in table 1.

Below, we break down the basic and recommended measures:

BASIC MEASURES OF COMPLIANCE

-Proper training in airway manipulation (aspiration of bronchial secretions) (Level of evidence high. Strong recommendation): In the first phase of implementation of the program, establishes a training plan aimed at appropriate training in handling of the airway (aspiration of bronchial secretions) by nursing. Training of health personnel it is a fundamental factor, since inexperience is associated with an elevation of adverse effects¹⁶. Habitually, there is an increase in infection rates or the appearance of outbreaks during holiday periods, and staff ratios can be altered, professional inexperience is more frequent. The formation specificity of the health workers involved in the treatment of patients through educational programs has been associated with excellent results in the prevention of nosocomial infections, and they are very highlighted the results of those dedicated to prevent bacteremia related to catheter.¹⁶

-Strict hand hygiene with alcohol-based products (PBA) before manipulating the airway (High evidence level. Strong recommendation). Despite being a concept that comes from the nineteenth century, compliance remains a challenge today. It has been the first objective chosen by the World Health Organization in launching the alliance for patient safety¹⁷. The concept “Clean care is safe care” is especially relevant in ICUs, since every hour there are up to 30 opportunities to disinfect the hands, which requires a time that competes with that of assistance.

The incorporation of alcoholic solutions has allowed to reduce the time necessary to perform hygiene and thus approach a more acceptable level of compliance than those observed with traditional washing¹⁶.

- Oral hygiene using chlorhexidine (0.12% - 0.2%)¹¹. (Level of Evidence high. Strong recommendation).

- Control and maintenance of pneumo pressure above of 20 cm H₂O. (Moderate evidence level, strong recommendation). The maintenance of a correct pneumatic pressure (Pcuff) is essential^{18, 19, 20}. Excessive pressure can alter the microcirculation of the tracheal mucosa and cause ischemic lesions^{21,22}, and an insufficient Pcuff prevents ventilation with positive pressure and can allow the entry of subglottic secretions between the tube and the trachea. Rello et al analyzed the effect that pneumotaponation control had on the development of VAP in the first 8 days of MV and demonstrated that a Pcuff greater than 20cm H₂O in a sustained manner was associated with a lower risk. However, the multivariate analysis could only demonstrate that Pcuff less than 20cm H₂O in a sustained manner was an independent risk factor in the subgroup of patients without antibiotic treatment²³.

- Avoid, when possible, the supine position at 0°. (Level of moderate evidence. Strong recommendation). The supine favors gastroesophageal reflux and, therefore, an increase in the amount of secretions accumulated in the subglottic space²⁴. It has been shown that the semi-incorporated position of the ventilated patient decreases the incidence of VAP (23% in the supine position and 5% in the semi-incorporated position, p = 0.018). This effect is much more evident when the patient is nourished enterally²⁵. However, some authors²⁶ have found it difficult to maintain the position at 45 ° continuously in all critical patients²⁷.

- Favor all procedures to reduce intubation and / or its duration¹⁶ (Level of evidence low. Strong recommendation).

- Avoid programmed changes to the nozzles, humidifiers and tracheal tubes¹¹. (High evidence level. Strong recommendation).

HIGHLY RECOMMENDED SPECIFIC OPTIONAL DATA

- Continuous aspiration of subglottic secretions. (High level of evidence. Strong recommendation). The evidence of its effectiveness is high, in especially in early pneumonia. The suction system, at low pressure, it must be continuous and its proper functioning will be monitored every 8 hours. In the case of doubts of its correct operation introduce 2 ml. of saline by the aspiration system¹⁶. Its implementation will depend on the availability of endotracheal tubes with aspiration systems in ICUs.

EXTRA MEASURES ADOPTED IN OUR UNIT

- Enteral nutrition connection once the patient has already been washed and after the change of bed and suspension of bedding in all mechanical ventilation withdrawal maneuvers.
- Use of Mallindrock Hi-Lo™ and TaperGuard orotracheal tubes with subglottic aspiration since clinical evidence suggests that the microaspiration may play a role in a portion of complications postoperative lung diseases²⁸. In the subglottic space there are an amount of secretions from the oropharynx or the gastrointestinal tract, it is an established fact by performing radiographs²⁸ or quantifying the material obtained by local aspiration²⁹. The colonization, endogenous or exogenous, of these secretions is a practically inevitable fact,

and the causal relationship with VAP is well established since ninetens³⁰⁻³³. Preventive measures aimed at avoiding VAP include decreasing the amount of secretions, preventing passage between the tube and the tracheal wall, aspirating the secretions or sterilizing them.

- Posters of preventive measures of VAP.
- Knowledge of monthly VAP rates thanks to the ENVIN record.
- Monthly session for evaluation of the results, feedback and reinforcement of the measures adopted to reduce the incidence of VAP.

Now just a year ago our units began to admit patients with respiratory failure in the context of the SARS-CoV-2 pandemic. In a short period of time they had to expand the number of critical beds and adapt the human resources to this new situation. The own conditions of COVID-19 patients and the enormous healthcare burden that had to be faced during the first months of the pandemic affected and changed the usual work dynamics in the units.

In June 2020, the advisory committee for safety projects in critical patients, Tolerance Zero, of the Ministry of Health, before the perception by the healthcare personnel of a significant increase in healthcare-related infections (HAI), issued a statement recommending, among other measures, a retrospective study to analyze the IRAS identified in COVID-19 patients.

DATABASE

Regarding the statistical study, the database was register ENVIN-HELICS¹, <http://hws.vhebron.net/envin-helics/>.

The database in SQL Server is located on a corporate server and accessed through a web page (hws.vhebron.net/envin-helics/). The information is presented in a descriptive way. Categorical variables are described

as a percentage of each category and the continuous variables as means and standard deviation or medians and interquartile range. Statistical analyzes have been developed in programs written in asp language, visual basic and in SPSS.

The Foundation for Biohealth Research in Eastern Andalusia (FIBAO) has been responsible for performing the statistical analysis, the data has been worked with the Poisson regression, which is detailed below.

Poisson Regression determines if there are differences in the occurrence of pneumonias considering as a factor the year of observation, and variable weight of scale the incidence rate for every 100 patients admitted to ICU. The Omnibus test of the model indicates that the regression model is statistically significant ($p_value = 0.000$), so it is appropriate to study its results. The variability explained by the model is 44.20%.

It has been used Wald's confidence interval, and for the hypothesis contrast the Wald chi square.

Frequency measures: Incidence density (ID) of each of the controlled infections have been used as a frequency indicator. The ID of each infection analyzed includes in the numerator the absolute number of cases of the infection analyzed and in the denominator:

a) the number of risk days for all patients admitted, per thousand, or

b) the number of days of presence of the risk factor related to each infection, per thousand.

RESULTS

The first thing we want to explain is the profile of the patients that we have entered during these nine years (table 2). We have a total of 9595 patients doing a general descriptive study from 01/04/11 to 31/12/19. Our patients' profile is described in table 2.

The variable year is statistically significant in the model ($p_value = 0,000$). 2011 has been set as year of contrast so all the results are compared to this date: It has been set as year of contrast 2011(before NZ and after NZ), so all the results are compared to this date, 8.73/dMV(mechanical ventilation days), we explain it in table 3.

In graph 1 these data are represented.

Regarding the educational phase, comment that 100% of the staff made it, as well as part of the Anesthesia and Resuscitation service. In total, 137 people participated.

The highest grade was obtained by the staff doctors followed by the nursing assistants (Supplementary Table S1).

DISCUSSION

The staff's participation in the unit has been high, as well as their involvement in the educational program and in the subsequent implementation. The success of NZ would not have been possible without the interest they have shown.

The qualifications were quite high considering that maximum grade was 30. This indicates that they have studied and taken training seriously.

In the light of the results, they have been able to apply the knowledge, since the VAP has descended.

Since the beginning of the implantation, there has been a gradual decrease with some point rebound. We attribute this increase in rates to the change in the hydroalcoholic solution facilitated by Pharmacy since a series of cutaneous conditions appeared in the hands of professionals who used it during the year 2013, it was finally removed from circulation and replaced by the previous one, with what it returned to be used and to realize of adequate way the hygiene of hands. This incident was notified to those responsible for the project, and appropriate action could be taken.

In each year, variability has been observed in different seasons, increasing these rates in summer, relating directly to the recruitment of untrained personnel¹⁶. The figures improved at the end of the holiday season with the learning of the protocol by the new staff. Although they did not participate in the initial educational phase, they were trained by their own colleagues at the beginning of their contracts in July, assimilating the knowledge quickly, 1 month -2 months later, VAP figures returned again. This also demonstrates the internalization of both the importance of the project and the knowledge acquired. It has to be noted that in summer there is a raised in nurse ratio and there are a reorganization of the unit in base to statistical studies wich says that we have a lower number of patients because of the holidays, so we have closed boxes and, sometimes, the same number of patients, haciantion could be another factor to take into account^{27,28}.

Since the beginning of the educational program, VAP have been gradually decreasing. At the beginning of the NZ program, we presented rates that were very above the recommended value. Number of pneumonia according to IT has decreased with respect to the year 2011, being this decrease statistically significant in 2012, 2014, 2015 and 2018. The difference in 2018 is statistically significant compared to 2012 and 2014 (0.044 y 0.029 respectly).

In 2015 and 2016, there has been a slight increase in the number of NAV but, it should be noted, the number of revenues has been higher, so that studied globally, does not imply an increase in rates. The reason why these years ID was so high, is because a process of separation from neurotraumatology began and we had again our cardiological and multipurpose ICU. A lot of new staff joined us and we had to go back to training and start from 0.

We began this journey with a higher number of NAV than our Spanish colleagues, and well above the Europeans and Americans. From 2012 to 2015, the figures have fallen below Spanish ones¹: 2011 9,41/dMV; 2012 7,27/dMV; 2013; 2014; 2015 5,77/dMV. Taking into account that SAPS III and APACHE II indicate that patients have a similar degree of severity in the rest of the Spanish ICUs¹ compared with ours, the data would be comparable.

Regarding the germs and the systemic response, we can affirm that the germs vary according to the flora of the unit and the antibiotics used, this would be the basis for another study. It is interesting to note that we have not observed septic shock in any case, remaining in sepsis or severe sepsis.

The most important element in the success at the time of implementing the project has been the effort and tenacity of the staff. Their involvement in the educational phase and the interest shown, translate into great grades in the final evaluation. In a short time they have internalized and normalized in their daily practice the recommendations making it something routine. It is also worth mentioning the work they have done teaching new colleagues hired for summer substitutions, managing to overcome the figures that worsened at the beginning of the holiday period.

The result of this has been the improvement in the figures of VAP, not only adjusting to the limit proposed by SEMICYUC, but improving it widely. Number of pneumonia has decreased with respect to the year 2011, being this decrease statistically significant in 2012, 2014, 2015 AND 2019. We note again that in 2013 the worsening of the change in the alcohol solution for hand washing is attributed. This fact also makes us think that it is of vital importance to bear in mind that to comply with the protocols it is necessary

to adjust in a certain way to the needs of the workers, since when the alcohol solution damaged their hands, it was no longer used and to change it by another one, its use was recovered again improving the VAP figures again thanks to the hand hygiene.

We can conclude that NZ project is accompanied by an improvement in VAP figures. The information contained in this report is the result of a significant effort made during a period of time in which ICUs have continued to be under high pressure care, but without a doubt it has been an effort that has been worthwhile because it provides us with data important information on the impact of HAIs in this group of patients, and highlights the need to recover prevention programs (Project Zero) as soon as possible, as well as the strategies to adapt them to the situation generated by the pandemic.

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BASIC	RECOMMENDED	OUR MEASURES
Training in airway manipulation Hand hygiene Oral hygiene with chlorhexidine Pneumo pressure above of 20 cm H ₂ O Avoid supine position at 0° Reduce time intubated Avoid programated changes in the airway	Continous subglotic aspiration	Timming of enteral nutrition connection Subglottic aspiration Posters of preventive measures of VAP Monthly VAP rates Monthly evaluation of the results

Table 1. Basic and recommended measures.

PATIENTS PROFLE
Age: 62 '75 ± 15 '98
Gender: man 65 '43% Base disease: coronary 42 '46%, medical 41 '34%, surgycal 12 '79%, traumatology 3 '41% Exitus. No 91 '78% SAPS II: 33 '14 ± 16 '53 APACHE 13 '03 ± 8 '69 Stay: 4 '97 ± 10 '35 days Antibiotic treatment in ICU: 32,36%

Table 2: Profile of our patients.

Year		
2012		
2013		
2014		
2015		
2016		144
2017	0	
2018	10.22	=0.906
2019	3.6	<0.001

Table 3: Results.