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Research Article

Mechanical Ventilation in Low-Resource Setting: A Descriptive Analysis of Two Year Experience at Piedras Negras, Coahuila, Mexico

Jose Ivan Rodriguez de Molina Serrano*

ICU Head at Clinica Mexico, Medical Staff at General Hospital 11 IMSS Piedras Negras, Coahuila, Mexico

***Corresponding Author:** Jose Ivan Rodriguez de Molina Serrano, ICU Head at Clinica Mexico, Medical Staff at General Hospital 11 IMSS Piedras Negras, Coahuila, Mexico.

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Abstract

Epidemiology of MV in low-resource setting is lacking [3] Piedras Negras, is north of Coahuila, Mexico [5]. Zone 11 General Hospital IMSS (public) and Clinica Mexico (private) ICUs have one critical care physician, general nurses, 2 beds fully equipped, 2 ventilators. We described demographics, diseases, severity, mortality and quality of attention. Methods: retrospective study November 2016 March 2019 information: demographics, diagnosis, origin site, admission factor, LOS, complications, SOFA, SAPS3, qSOFA and quality of attention indicators. Goodness of fit test and T-test were used for p value < 0.05, Mid-P exact test for SMR (StatCalc 1500 1.3 © AcaStat software 2018). Results 178 patients: Female 50.6% p = 0.88, Activity status functional 61.8%, admission site ER 50%, diagnosis Sepsis 31.5%, STEMI 7.3% and DKA 6.3% p < 0.0001. Age 47.4 years + 2.89, SOFA 7.5 + 0.96, SAPS3 59.5 + 3.06, ICU LOS 2.9 days + 0.5, Hospital LOS 5.5 days + 1.08 p < 0.0001. ICU mortality 14.61% and Hospital 23.6%, 20.8% were transferred p < 0.0001. 92 MV patients which had longer LOS ICU 6.5, Hospital 12.2 days p < 0.0001, higher SOFA 11.7 and SAPS3 71.5, Mortality 27.17% (ICU) and 40.2% (Hospital) p < 0.0001, SMR 0.72 CI 95% 0.52 - 0.98 p < 0.001. Diagnosis: Sepsis, Post CPR, severe TBI (50%, 11% and 8.7% p < 0.0001). Nosocomial pneumonia 18.5%, 7.6% accidental extubation and 13% unexpected cardiac arrest p < 0.0001. ARDS 33 patients, severe 57.6% p < 0.0001. quality indicators: ulcer-stress prophylaxis 97.2%, DVT prophylaxis 86.9%, VAP 26.6 per 1000 days of MV, Accidental extubation 14.3 events per 1000 days of MV, Reintubation rate 7.5%, ICU weakness 57.1%.NIMV was also used in 12 patients: 92% p < 0.17 were treated in Clinica México, 41.7% p < 0.78 were transferred, shorter LOS ICU 2.4 days + 1.7, Hospital 3.4 days + 2.3 p < 0.0003. MV in low-resource setting is a primordial need of critical care patients, our mortality was reported lower than expected but quality of attention indicators most be improved in order to maintain this trend. Despite several limitations in population and applicability our study contributes with primordial information about two low-resource settings that treated MV critical care patients.

Keywords: *Intensive Care Unit; Emergency Room; Traumatic Brain Injury; ST-elevation Myocardial Infarction*

Abbreviations

MV: Mechanical Ventilation; IMSS: Instituto Mexicano del Seguro Social; SAPS 3: Simplified Acute Physiology Score 3; qSOFA: quickSOFA; SOFA: Sequential Organ Failure Assessment; SD: Standard Deviation; TBI: Traumatic Brain Injury; ICU: Intensive Care Unit; ER: Emergency Room; OR: Operating Room; STEMI: ST-elevation Myocardial Infarction; DKA: Diabetic Ketoacidosis; ARDS: Acute Respiratory Distress Syndrome; DVT: Deep Vein Thrombosis; VAP: Ventilator Associated Pneumonia; RRT: Renal Replacement Therapy, PCI: Percutaneous Coronary Intervention

Introduction

Critical care medicine faces challenges as part of the development of health system worldwide, making it necessary even at places where the infrastructure or the health personal is lacking [1]. All hospitals independently of their resources have critical care patients, this is independent of the technology available in-site [1]. Even though the most critical interventions: fluid management, early antibiotics and basic hemodynamic monitoring have a very low cost [1]. Mechanical Ventilation remains the cornerstone in the supportive management of patients with respiratory failure and is one of the interventions that define critical care medicine as a speciality [2]. The first formal use of MV in modern medicine was describe by Dr. Bjorn Ibsen in Copenhagen 1953 with polio patients, reducing mortality from 87% to 25% [3]. There is a trend to believe, that critical care patient attention is not cost-effective in low-resource settings, nevertheless it is proven that the patients treated in this settings are younger and healthier than the ones treated in third level or specialized centers [1]. Epidemiology of MV in low-resource setting is lacking, the majority of published data comes from large urban centers often with university affiliation rather than from provincial or district level facilities [3]. Despite these limitations there is a consistent high crude mortality reported from 36% to 72% [4]. Piedras Negras, Coahuila has a population of 150,172, having the reference hospital centers at 2 - 4 hrs road trip [5]. Zone 11 General Hospital from IMSS (public health system) has 99 hospital beds, 2 operating rooms and provides medical care to 600 - 700 patients per month, critical care unit has 2 beds, 2 ventilators, invasive and non-invasive monitoring; The nursery staff is constituted with specialized nurses morning and afternoon shift, night shift is covered with general nurses; medical staff is constituted with one critical care physician Monday to Friday, in morning shift, rest of the shifts and weekends is covered with internal medicine physicians that are in charge of whole hospital. Clinica Mexico (private hospital) with 20 beds, 4 operating rooms, 2,600 admissions annually; critical care unit is closed with one critical care physician in charge of medical treatment and administrative issues, general nurses were trained by 6 months in order to provide the attention to critical care patients, it has 2 beds, 2 ventilators, invasive and non-invasive monitoring and ultrasound equipment in place for lung, heart and vascular access. Despite the availability of mechanical ventilation in public and private practice very few studies have looked at the outcomes in unselected patients. The experience acquired in the practice of mechanical ventilation in low-resource setting provides information to assess the need and results from this sites. The purpose of this study was to describe demographics characteristics, common diseases, severity, mortality, the quality of attention of critical care patients cared at two Intensive Care Units at Piedras Negras, Coahuila, Mexico.

Methods

We conducted a retrospective study from November 2016 to March 2019 of consecutive patients admitted at Zone 11 General Hospital IMSS and Clinica Mexico, registered at the data base of each unit. At Zone 11 General Hospital only patients treated by the critical care physician were recorded, all patients at Clinica Mexico were admitted. We collected general demographic characteristics, diagnosis, origin service, previous in-hospital location, priority, admission factor, length of stay in ICU and hospital, procedures, quality indicators and complications, severity of disease, organ failure sequential assessment, SAPS 3 and qSOFA. Using this data we calculate the quality indicators: Stress ulcer prophylaxis, Deep vein thrombosis prophylaxis, Ventilator-associated pneumonia, Medication mistakes, extubation failure, TBI mortality, ICU weakness.

The quantitative variables were described in mean + SD, qualitative in frequency and percentage, Goodness of fit test was made for significance distribution of qualitative variables with a $p < 0.05$ T-test for quantitative variables with a $p < 0.05$, Mid-P exact test was performed to evaluate the standardized mortality ratio of mechanical ventilated patients with $p < 0.05$, quality of attention indicators were calculated as specified in Guias de calidad de Atencion de SEMCyUC. Statistical analysis was performed with StatCalc version 1500 1.3 © AcaStat software 2018.

Results

We collected 178 patients during the study period. 92 patients required mechanical ventilation. Main characteristics of total population were: Female 50.6% $p = 0.88$, Activity status defined as functional in 61.8% $p < 0.0001$, primary site of origin were ER 50%, Ward

20.2% and OR 16.3% p < 0.0001, admission factor was Threat of organic failure in 39.9%, Need of Mechanical Ventilation 28.7% and Shock 18% p < 0.0001, main diagnoses were Sepsis 31.5%, STEMI 7.3% and DKA 6.3% p < 0.0001. The mean age of the patients was 47.4 SD + 2.89 p < 0.0001, mean SOFA 7.5 SD + 0.96 p < 0.0001, mean SAPS3 59.5 SD + 3.06 p < 0.0001, ICU length of stay 2.9 days SD + 0.5 p < 0.0001, Hospital length of stay 5.5 days SD + 1.08 p < 0.0001. ICU mortality was 14.61% p < 0.0001, Hospital mortality was 23.6% p < 0.0001 and 20.8% p < 0.0001 patients were transferred to other hospital. Mortality calculated with SAPS3 was 37.2% SD + 4.5% p < 0.0001 (Table 1).

	Total n = 178	**MECH VENT n= 92**	**p**
Male n (%)	88 (49.4%)	47 (51.1%)	0.8
Age, years (SD)	47.4 (+19.5)	48.9 (+19.4)	< 0.0001
ICU LOS (SD)	2.9 (+4.5)	6.5 (+5.9)	< 0.0001
Hospital LOS (SD)	5.5 (+9.2)	12.2 (+12.8)	< 0.0001
SOFA (SD)	7.5 (+6.5)	11.7 (+5.8)	< 0.0001
SAPS 3 (SD)	59.4 (+20.7)	71.5 (+17.7)	< 0.0001
SAPS 3 Mortality (SD)	37.2% (+30.5)	55.5 (+25.8)	< 0.0001
qSOFA (SD)	1.6 (+0.9)	2.1 (+0.8)	< 0.0001
	Outcomes		
ICU mortality n (%)	26 (14.6%)	25 (27.17%)	< 0.0001
Hosp mortality n (%)	42 (23.6%)	37 (40.2%)	< 0.0001
Transferred n (%)	37 (20.8%)	15 (16.3%)	< 0.0001
	Administrative category		
Private n (%)	46 (25.8%)	28 (30.4%)	< 0.0001
Medical Insurance n (%)	27 (15.2%)	11 (12%)	< 0.0001
Public Health System n (%)	105 (59%)	53 (57.6%)	< 0.0001
	Previous Activity and Health Status		
Functional (%)	110 (61.8%)	49 (53.3%)	< 0.0001
Symptomatic n (%)	59 (33.2%)	37 (40.2%)	< 0.0001
Walks < 50% n (%)	5 (2.8%)	2 (2.17%)	< 0.0001
Inbed n (%)	4 (2.3%)	4 (4.4%)	< 0.0001
	Site of origin		
ER n (%)	89 (50%)	42 (45.6%)	< 0.0001
Ward n (%)	36 (20.2%)	23 (25%)	< 0.0001
OR n (%)	29 (16.3%)	14 (15.2%)	< 0.0001
Other hospital n (%)	19 (10.7%)	11 (12%)	< 0.0001
Other n (%)	5 (2.8%)	2 (2.2%)	< 0.0001
	Admission factor		
Threat to organic failure n (%)	71 (38.9%)	8 (8.7%)	< 0.0001
Mechanical Ventilation n (%)	51 (28.7%)	45 (48.9%)	< 0.0001
Shock n (%)	32 (18%)	28 (30.4%)	< 0.0001
Other n (%)	24 (14.4%)	11 (12%)	< 0.0001
	Diagnosis		
Sepsis n (%)	56 (31.5%)	46 (50%)	< 0.0001
STEMI n (%)	13 (7.3%)	2 (2.17%)	< 0.0001
DKA n (%)	11 (6.2%)	0	< 0.0001
Otros n (%)	98 (55%)	44 (47.83%)	< 0.0001

Table 1: *Main Characteristics of critical care patients at Piedras Negras Coahuila 2016-2019.*

Abbreviations: ICU: Intensive Care Unit; ER: Emergency Room; OR: Operating Room; SAPS 3: Simplified Acute Physiology Score 3; qSOFA: quickSOFA; SOFA: Sequential Organ Failure Assessment; SD: Standard Deviation; STEMI: ST-elevation Myocardial Infarction; DKA: Diabetic Ketoacidosis.

In comparison, Mechanical ventilated patients had longer ICU length of stay: 6.5 days p < 0.0001, Hospital LOS 12.2 days p < 0.0001, higher organic failure assessed by SOFA 11.7 vs 7.5 p < 0.0001 and SAPS 3 71.5 vs 59.4 p < 0.0001. ICU and Hospital mortality was higher 27.17% and 40.2% p < 0.0001 but was lower compared with mortality expected by SAPS 3 55.5% p < 0.0001, The standardized mortality ratio was 0.72 CI 95% 0.52-0.98 p < 0.001. Symptomatic patients were 40.2% p < 0.0001 of this population. Main site of origin were ER and Ward (45.6% and 25% p < 0.0001) similar than in general population. There was a significant difference in admission factor as expected: Mechanical Ventilation 48.9% vs 28.9% p < 0.0001 and Shock in 30.4% vs 18% p < 0.0001. Primary diagnosis was Sepsis 50% vs 31.5% p < 0.0001, and different from general population, Post cardiac arrest management and Severe Traumatic Brain Injury were second and third diagnosis in frequency (11% and 8.7% p < 0.0001).

Nosocomial pneumonia before ICU was present in 18.5% (p < 0.0001) of mechanically ventilated patients, 7.6% (p < 0.0001) patients presented accidental extubation, 3.26% (p < 0.0001) pneumothorax, 3.3% bronchoaspiration and 13% (p < 0.001) unexpected cardiac arrest. ARDS was diagnosed in 33 patients and was severe in 57.6% (p < 0.0001).

8 patients underwent tracheostomy for prolonged weaning, main diagnoses were Sepsis, severe TBI and Post cardiac arrest management.

Organic failure assessed by mean SOFA points were: Respiratory 2.2 SD + 1.5 p < 0.0001, Cardiovascular 3.0 SD + 1,5 p < 0.0001, Neurologic 2.6 SD + 1.6 P < 0.0001. The quality indicators of medical attention were ulcer stress prophylaxis 97.2%, DVT prophylaxis 86.9%, VAP 26.6 per 1000 days of MV, Accidental extubation 14.3 events per 1000 days of MV, Reintubation rate 7.5%, Weakness acquired in ICU 57.1% and mortality from severe TBI 0%.

Non-invasive mechanical ventilation was also used in 12 patients in this group. The main characteristics were: female 66.7% p < 0.25, 92% p < 0.17 were treated in Clinica México (private practice), previous health status was primary symptomatic in 58.3% p < 0.10, admission factor was as expected mechanical ventilation 50% p < 0.26. ICU mortality was 16.67% p < 0.34 and Hospital mortality 25% p < 0.78 with 41.7% p < 0.78 transferred to other hospital. Patients were older 56 years SD +16.1 p < 0.0001, length of stay was shorter ICU LOS 2.4 days SD + 1.7 p < 0.0005, Hospital LOS 3.4 days SD + 2.3 p < 0.0003. This sub-population had lower SAPS3 67.8 + 22.4 p < 0.0001, and SOFA 10.3 + 7.1 p < 0.0001 (Table 2).

	NIMV n = 12	MECH VENT n= 92	p
Male n (%)	4 (33.3%)	47 (51.1%)	0.24
Age, years (SD)	56.0 (+16.1)	48.9 (+19.4)	< 0.0001
ICU LOS (SD)	2.4 (+1.7)	6.5 (+5.9)	< 0.0001
Hospital LOS (SD)	3.4 (+2.3)	12.2 (+12.8)	< 0.0003
SOFA (SD)	10.3 (+7.1)	11.7 (+5.8)	< 0.0004
SAPS 3 (SD)	67.8 (+22.4)	71.5 (+17.7)	< 0.0001
SAPS 3 Mortality (SD)	48.4% (+30.5)	55.5 (+25.8)	< 0.0001
qSOFA (SD)	2.1 (+0.9)	2.1 (+0.8)	< 0.0001
Hours in MV SD	34.7 (+33.9)	133.8 (+120.9)	< 0.0001
	Outcomes		
ICU mortality n (%)	2 (16.7%)	25 (27.17%)	< 0.34
Hosp mortality n (%)	3 (25%)	37 (40.2%)	< 0.77
Transferred n (%)	5 (41.7%)	15 (16.3%)	< 0.77
	Administrative category		
Private n (%)	6 (50%)	28 (30.4%)	< 0.17
Medical Insurance n (%)	5 (41.7%)	11 (12%)	< 0.17
Public Health System n (%)	1 (8.3%)	53 (57.6%)	< 0.17

	Previous Activity and Health Status		
Functional (%)	4 (33.3%)	49 (53.3%)	< 0.10
Symptomatic n (%)	7 (58.3%)	37 (40.2%)	< 0.10
Walks < 50% n (%)	1 (8.3%)	2 (2.17%)	< 0.10
Inbed n (%)	0	4 (4.4%)	< 0.10
	Site of origin		
ER n (%)	4 (33.4%)	42 (45.6%)	< 1.0
Ward n (%)	4 (33.3%)	23 (25%)	< 1.0
OR n (%)	0	14 (15.2%)	< 1.0
Other hospital n (%)	4 (33.3%)	11 (12%)	< 1.0
Other n (%)	0	2 (2.2%)	< 1.0
	Admission factor		
Threat to organic failure n (%)	2 (16.7%)	8 (8.7%)	< 0.26
Mechanical Ventilation n (%)	6 (50%)	45 (48.9%)	< 0.26
Shock n (%)	2 (16.7%)	28 (30.4%)	< 0.26
Other n (%)	2 (16.6%)	11 (12%)	< 0.26
	Diagnosis		
Sepsis n (%)	5 (41.7%)	46 (50%)	< 0.31
STEMI n (%)	1 (8.2%)	2 (2.17%)	< 0.31
DKA n (%)	0	0	< 0.31
Other n (%)	6 (50%)	44 (47.83%)	< 0.31

Table 2: *Invasive mechanical ventilated patients and non-invasive mechanical ventilated patients.*
Abrreviations: ICU: Intensive Care Unit; ER: Emergency Room; OR: Operating Room; SAPS 3: Simplified Acute Physiology Score 3; qSOFA: quickSOFA; SOFA: Sequential Organ Failure Assessment; SD: Standard Deviation; STEMI: ST-elevation Myocardial Infarction; DKA: Diabetic Ketoacidosis; NIMV: Non-invasive Mechanical Ventilation.

In this subpopulation the only complication reported was unexpected cardiac arrest 1 patient (8.3% p < 0.004). ARDS was diagnosed in 50% of them and only 2 (33.3% p < 0.41) was severe.

Discussion

In Mexico and worldwide there is lack of information of MV given in low resource setting. Of the 178 patients treated in a two year time frame, 92 (51.6%) needed MV, as expected it was higher than reported in normal or high resource-settings in international studies (33%) [6], in counterpart, Ayub F., *et al*. [8] reported 112 patients with MV in a two year time frame at low-resource setting in Pakistan, in this study they reported 80% of patients with MV at ICU [9]. General population characteristics had a slightly predominance of Female 50.6% p < 0.88, this is different from reported in literature, Cubro., *et al.* [9] in a cost-effectiveness study at Sarajevo reported Male predominance with 56%; this difference could be explained on population basis: Piedras Negras Female population is 50.3% of total [5]. The median age was 47.4 years SD + 19.5 it was younger as compared with European data that reported a mean age of 56 years SD + 17 [9] but the trend is to report younger patients and sometimes healthier in low resource-settings [1] in this issue we reported 61.8% p < 0.0001 of patients had a activity and health status defined as functional, previous admission.

The primary diagnosis in this population was Sepsis 31.5% p < 0.0001; Carrillo., *et al.* [10] reported 27.1% of septic patients in 135 ICU at Mexico; International data reports 6%-30% ICU admissions with this diagnosis [11,12]. The mortality in ICU and hospital was 14.6% and 23.6% p < 0.0001, international data reports [9] higher ICU and hospital mortality 38.5% and 48% [9]. We reported a 37 patients (20.8%) were transferred to other hospital, the main reasons were economic and lack of resources or medical specialities (RRT, cardiac surgery, PCI).

Patients on MV were male 51.1% p < 0.88, Ming-Jang., *et al*. [13] in Taiwan reported male 61%, Esteban., *et al*. [2] reported male 59.6%, nevertheless this was the only demographic characteristic that didn´t reach statistical significance, recently Marin., *et al*. [14] reported in epidemiological study of 959 patients in Mexico with MV in ICU a Male predominance with 66%. The mean age of this MV patients was 48.9 SD +19.4, this was similar in Mexican patients; 48 years SD + 20.5 [13]; international data reported and interval from 38 - 61 years [6-8] this could be different because we treat adult patients. MV patients have higher LOS compared with general population (ICU 6.5 days SD +5.9 vs Hospital 12.2 days SD +12.8 p < 0.0001), this was concordant as reported internationally studies ICU LOS 7 days IQR 4 - 14, Hospital LOS 17 days IQR 9 - 31 [6], national data also reports similar LOS in ICU and Hospital [13].

Mechanical ventilation is expensive in our study 30.4% of patients were Private (Self-pay), this is higher compared with data reported by Mehta A., *et al.* [15] in a retrospective study of MV in Hospital with 51.689 patients of 274 hospital in California, USA, in which they reported only 1% of self-pay, 13.4 - 15.7% of medical (private) insurances, 57.1% medicare 26.5% medicaid, we reported 12% medical insurances and 57.6% were treated at IMSS (public health system), even though both health systems aren´t comparable, the majority of mechanical ventilated patients are treated in facilities where the primary payer isn´t self-pay.

The majority of patients were reported as functional 50.3% and 40.2% were symptomatic (p < 0.0001), Balasubramanian K., *et al.* [16] reported 237 adult patients treated at low-resource setting in India a 50% comorbidity illness (Diabetes Mellitus, Hypertension, COPD).

Non-invasive mechanical ventilation treatment was reported in 13% of our patients, trending to be older (56 years) but with lower severity of disease, this is concordant with international reports 5 - 14% of patients with NIMV [4-6]; in Mexico 5 - 8% of patients were treated NIMV, age 57 - 75 years old and mortality range 15 - 27% [14]. We reported lower mortality but this sub-population had the highest transferred percentage with 41.7% p < 0.77.

The quality of attention indicators we reported met international standard in ulcer stress prophylaxis and reintubation rate and mortality from TBI, the ones that were above international standard were VAP, DVT prophylaxis, ICU acquired weakness and accidental extubation [19]. To our knowledge there is no data available with this specific indicators in low-resource setting, but it reported that 30 - 56% of patients had a complication associated with MV [3,4,7].

The limitations of our study were: we only assessed two ICU of the three ICU available at site, the third ICU is also part of public health system and emergency physicians are in charge of it. We only admitted patients that were treated for the only intensive care physician at IMSS this could represent gap in patients admitted and discharged during weekends, all data was recorded, and the statistical analysis was made for the author, that is also the only intensive care physician in the city.

Despite this limitations we believe that the epidemiological data reported in this study contributes to better profiling of patients treated in low-resource setting in Mexico and worldwide. The clinical outcomes (mortality) were better than expected, this reflects a committed team work (nurses and physician) in charge of MV patients and show the path for improvement.

Conclusion

In conclusion MV in low-resource setting is a primordial need of critical care patients, our mortality was reported lower than expected but quality of attention indicators most be improved in order to maintain this trend. This study has several limitations in population and applicability but contributes with primordial information about two low-resource settings that treated MV critical care patients.

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Volume 8 Issue 8 August 2019