MEDICAL SCIENCE MONITOR

PUBLIC HEALTH

e-ISSN 1643-3750
© Med Sci Monit, 2013; 19: 424-429
DOI: 10.12659/MSM.883930

Received: 2013.01.07
Accepted: 2013.04.04
Published: 2013.06.03

Mechanical ventilation in ICUs in Poland: A multi-center point-prevalence study

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ADEF 1 **Andrzej Kübler**
ABDF 2,3 **Dariusz Maciejewski**
CDEF 1 **Barbara Adamik**
ABF 3 **Małgorzata Kaczorowska**

1 Department of Anaesthesiology and Intensive Therapy, Wrocław Medical University, Wrocław, Poland
2 Department of Nursing, Faculty of Health Science, University of Bielsko-Biała, Bielsko-Biała, Poland
3 Anaesthesiology and Intensive Therapy Unit, District Hospital Bielsko-Biała, Bielsko-Biała, Poland

Corresponding Author: Andrzej Kübler, e-mail: andrzej.kubler@am.wroc.pl
Source of support: Departmental sources

Background: Mechanical ventilation is the primary method of supporting organ function in patients treated in intensive care units (ICUs). Lung damage from mechanical ventilation can be avoided by using the correct ventilation modes. This study was designed to assess the epidemiology and treatment strategies of patients receiving mechanical ventilation in ICUs in Poland.

Material/Methods: This study was done using a point-prevalence methodology. Questionnaires requesting demographic data, indications for ventilation, variables involved in ventilation, airway access, methods of sedation, and mode of weaning were sent to 148 ICUs.

Results: Eighty-three ICUs took part in the study. The rate of ventilated patients was 73.6%. The indications for mechanical ventilation were: acute respiratory failure (40%), coma (40%), chronic obstructive pulmonary disease (COPD) exacerbation (14%), and neuromuscular diseases (5%). Patients were ventilated by orotracheal tube (58%), tracheostomy tube (41%), and mask/helmet (1%). The mean tidal volume was 8 ml/kg and positive end-expiratory pressure was commonly used. The mean oxygen concentration was 40%. Synchronized intermittent mandatory ventilation with pressure support was the most frequently used ventilatory mode. Benzodiazepine and opioids were used for sedation in 91% of centers. A systematic testing of the depth of sedation was performed at 48% surveyed ICUs. Ventilation monitoring with biomechanical methods was used at 53% of centers.

Conclusions: Mechanical ventilation is commonly used in ICUs in Poland. Almost half of the ventilated patients had extrapulmonary indications. Patients were ventilated with low concentrations of oxygen, and positive end-expiratory pressure (PEEP) was commonly employed.

Key words: epidemiology • intensive care unit • mechanical ventilation • respiratory failure

Full-text PDF: http://www.medscimonit.com/download/index/idArt/883930

2420 4 — 17

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Background

Mechanical ventilation is the primary method of supporting organ function in patients treated in intensive care units (ICUs) and has become emblematic of the ICU because its use resulted in the creation of intensive care units and established intensive therapy as a separate medical field [1]. In recent years, a wide variety of ventilation strategies have become available because of new ventilators that offer complex modes and different parameters for ventilating and weaning patients from respirators. In the last decade it has become widely accepted that the lungs can be damaged by mechanical ventilation and that this can be avoided by using the correct ventilation modes [2]. As a result, the frequency and manner in which mechanical ventilation is used in the ICU has become an interesting epidemiological issue.

Epidemiological studies on the use of mechanical ventilation have used different research methodologies. A 1-day, point-prevalence study was first carried out in Spain [3] and then repeated in an international study involving centers in Spain, Portugal, and North and South America [4]. A similar project was done in Scandinavia [5]. Subsequent retrospective [6] and prospective observational studies were performed to obtain more precise information on the application of mechanical ventilation using more advanced epidemiological methodologies [7–11].

The main objective of our study was to describe the use of mechanical ventilation in the ICUs in Poland because there is no information available on the current patterns of use of mechanical ventilation for treating patients in our country. We decided to use the point-prevalence approach used in previous studies. Our study collected information in the form of completed questionnaires on the frequency and mode of mechanical ventilation in ICUs during a specific period of time (1 day) to make an overall assessment of mechanical ventilation strategies.

Material and Methods

This was a noninterventional, observational, and multi-center study in the form of a 1-day point-prevalence approach using a dedicated questionnaire. Participation in the project was voluntary. The study was performed on 31 January 2010. Questionnaires were sent to 148 accredited ICUs for adult patients (>18 years old) by e-mail, with a request to return the results on the day of the study to the administrative office of the Department of Anaesthesiology and Intensive Therapy, Wroclaw Medical University, Wroclaw, Poland, where statistical analysis was done. All ICUs received the questionnaire with complete information about the project 2 weeks in advance. All questions in the questionnaire were in reference to the status of ICU adult patients only on the day of 31 January. Questionnaires were completed by designated physicians at each site. The project was approved by the Bioethics Committee of the Medical University in Wroclaw.

The research questionnaire contained 29 multiple choice questions on the following areas:

A. *Demographic data*: information about the type and size of the hospital and the ICU, bed occupancy in the ICU, the number of patients on mechanical ventilation, and the age and sex of ventilated patients.

B. *The indications for mechanical ventilation*, broken into subgroups:
   a. acute respiratory failure;
   b. neuromuscular disease;
   c. chronic obstructive pulmonary disease (COPD) exacerbation;
   d. coma.

The causes of acute respiratory failure were then divided into: postoperative respiratory failure, sepsis/septic shock, pneumonia (without signs of sepsis and acute respiratory distress syndrome), trauma, cardiogenic pulmonary edema, aspiration, acute respiratory distress syndrome (ARDS), and other.

C. *The characteristics of ventilatory therapy:*

To assess different variables involved in ventilation, questions were asked about the range of values for: tidal volume, inspiratory rate, PEEP (positive end-expiratory pressure), procedures for determining PEEP, concentration of inspired oxygen, and ventilation mode.

D. Airway access: intubation, tracheostomy, noninvasive ventilation. The frequency and procedures for performing a tracheotomy. The frequency and policy of noninvasive ventilation (NIV). The mode and method of weaning a patient from the respirator.

E. *General strategy and methods of sedation*: the medications used in sedation, an assessment of the depth of sedation.

F. *Methods for biomechanical monitoring of ventilated patients*.

More than 1 answer could be checked if applicable. Questionnaire is available upon request from the corresponding author.

Statistical analysis

The data distribution was not normal (the Shapiro-Wilk test) and results were presented as the median with the first and

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Table 1. Indication for mechanical ventilation.

Acute respiratory failure n (%)	132 (40)
ARDS	5 (4)
Postoperative respiratory insuficiency	46 (35)
Cardiogenic pulmonary edema	12 (9)
Aspiration	5 (4)
Pneumonia	26 (20)
Sepsis/septic shock	18 (13)
Trauma	20 (15)
Coma n (%)*	132 (40)
COPD exacerbation n (%)	47 (14)
Neuromuscular disorders n (%)	16 (5)

* Including stroke, haemorrhage, metabolic coma, and cardiac arrest. COPD – chronic obstructive pulmonary disease; ARDS – acute respiratory distress syndrome.

third quartile (25th and 75th percentiles) or proportions (%). Results from university hospitals were compared with data from regional, community, and other facilities with the Mann-Whitney U test. Differences in values were considered statistically significant when the value for *p* was less than 0.05. Statistical analysis was performed with Statistica 9.0 (StatSoft Inc. Tulsa, OK, USA).

Results

There were 83 mixed surgical/medical ICUs from 83 hospitals around the country that took part in the study. The response rate was 56.1%. The hospitals were categorized as: county 41 (49%), regional 23 (28%), university 11 (13%), and other 8 (10%). The median number of beds in the hospitals surveyed was 373 (260, 560) and the median number of beds in the ICUs was 6 (5, 9).

There were 444 patients treated in the ICUs of participating hospitals on the study day and the bed occupancy rate was 71.9%.

Out of the total number of ICU patients, there were 327 (73.6%) patients on a respirator on the day of the study and they constituted the study group. There were 207 (63%) men and 120 (37%) women receiving mechanical ventilation. The median age of those patients was 63 years (57,74).

The main indications for mechanical ventilation were acute respiratory failure and coma. Other indications included COPD exacerbation and neuromuscular diseases (Table 1).

Table 2. Mechanical ventilation parameters (medians with 25th, 75th percentiles).

Tidal volume (ml/kg)	8 (7.1, 8.9)
Peak inspiratory pressure (cm H2O)	21.0 (18.5, 25.0)
Fraction of inspired oxygen	0.4 (0.35, 0.45)
Respiratory rate (breath/min)	13.0 (12.0, 15.5)
Patients ventilated with PEEP n (%)	266 (81)
PEEP value (cm H_2O)	5 (4.25, 6.4)

PEEP – positive end-expiratory pressure.

Table 3. Mode of ventilation.

SIMV + PS	117 (37%)
SIMV	57 (18%)
IPPV	46 (15%)
CPAP	36 (12%)
PCV/ BIPAP	32 (10%)
PSV	14 (5%)
Other	8 (3%)

SIMV + PS synchronized intermittent mandatory ventilation with pressure support; IPPV – intermittent positive pressure ventilation; CPAP – continuous positive airway pressure; PCV/BIPAP – pressure control ventilation/Bilevel Positive Airway Pressure; PSV – Pressure support ventilation.

The predominant cause of acute respiratory failure was postoperative respiratory insufficiency in 46 patients (35%), followed by pneumonia in 26 (20%), trauma in 20(15%), sepsis/septic shock in 18(13%), cardiogenic pulmonary edema in 12(9%), aspiration in 5 (4%), and ARDS in 5 (4%).

Values of ventilation parameters (tidal volume, peak inspiratory pressure, fraction of inspired oxygen, respiratory rate, and PEEP) collected on the day of the study are presented in Table 2. PEEP was used in 266 (81%) patients, with a median value of 5.0 (range 4.25–6.4) cmH_2O.

When asked about how ventilation was delivered, information was obtained for 323 patients, of which 189 (58%) were ventilated by an orotracheal tube, 131 (41%) by a tracheostomy tube, and 3 (1%) through a mask or helmet.

The ventilation mode varied, with a prevalence of modes supported by the spontaneous breathing of the patient: synchronized intermittent mandatory ventilation (SIMV) and pressure support (PS) (Table 3).

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

There were 81 ICUs that responded to the question about when the decision was made to do a tracheostomy. A majority – 58 (72%) – decided to perform a tracheostomy based on clinical indications, with no information given about the number of days the patient had already been on ventilation, 5 (6%) took the decisions to do a tracheostomy after 7 days of ventilation, 6 (7%) after 10 days, and 12 (15%) after 14 days. In 46 (57%) ICUs the tracheostomy was performed by an anesthesiologist, in 28 (35%) by an otolaryngologist, in 6 (7%) by a surgeon, and in 1 (1%) case by a doctor with a different specialization.

In response to the question about procedures used to determine PEEP, according to 47 responses (48%) PEEP was intuitively determined, according to 33 (33%) PEEP was determined on the basis of the PaO_2/ FiO_2 value, according to 11(11%) PEEP was based on the lowest point on the PV curve, and for 8 (8%) the PEEP value estimation was based on changes in lung compliance (respondents selected more than 1 answer).

Noninvasive ventilation (NIV) was used on 3 patients (1%) on the day of the study, but 30 (36%) ICUs reported that they use NIV when indications are present. The reported indications were: COPD in 13 (44%), weaning off the respirator in 10 (33%), cardiogenic pulmonary edema in 4 (13%), and other in 3 (10%). The interface mode when using NIV was most often a face mask in 13 (43%), followed by mask over the nose in 8 (27%), oro-nasal mask in 7 (23%), ventilation helmet in 1 (3%), and other in 1 (3%).

Weaning a patient off a respirator was done in accordance with hospital procedures at 18 (22%) centers and without an established protocol in 64 (78%) centers. Weaning was performed with pressure support (PS) in 29 (22%) centers, synchronized intermittent mandatory ventilation (SIMV) at 9 (17%) centers, and SIMV + PS at 39 (20%) centers, with spontaneous breathing tests as ordered at 35 (26%) centers, with daily spontaneous breathing tests at 15 (11%) centers, and with other methods at 6 (5%) centers (respondents selected more than 1 answer).

The drugs most often administered to sedate patients during mechanical ventilation were benzodiazepines and opioids in 76 (91%) centers. Other combinations of medication used to sedate patients were propofol and opioids at 12 (13%) centers, benzodiazepines and muscle relaxants at 5 (5%) centers, and benzodiazepines, muscle relaxants, and opioids at 2 (2%) centers (respondents selected more than 1 method).

Systematic testing of the depth of sedation was done at 40 (48%) out of 83 surveyed ICUs. A predetermined scale was used at 21(26%) ICUs, 6 (7%) ICUs used instrumental methods of evaluating the level of sedation (Bispectral Index, etc.), and 15 (18%) used other methods of evaluation.

Biomechanical methods of monitoring ventilation were reported to be used at 44 (53%) centers; 36 (41%) centers used lung compliance, 25 (28%) used flow/volume curve, 24 (27%) used pressure/volume curve, and 3 (4%) used other parameters (respondents selected more than 1 method).

Variability of the results based on hospital type

The comparative analysis of results based on the hospital type – university hospitals (Group 1) *vs.* regional, community and other hospital facilities (Group 2) – was performed. The median number of ICU beds was 12 (6, 13) in Group 1 and 6 (5, 8) in group 2 ($p<0.05$). Bed occupancy was 92% (58, 100) in Group 1 and 66% (56, 86) in Group 2. Acute respiratory failure was more frequently an indication for mechanical ventilation in Group 1 than in Group 2 ($p<0.05$). On the day of the study, acute respiratory distress syndrome was diagnosed only in patients treated at university hospitals.

Discussion

This multicenter study was designed to evaluate the policies and procedures of administering mechanical ventilation in Poland. In a similar international 1-day study published in 2000, there were 412 ICUs and 1638 ventilated patients [4], and in a 2002 Scandinavian study there were 27 ICUs and 108 ventilated patients [5]. The results of these 3 studies with the same methodology are compared in Table 4.

In the Polish study as many as 74% of patients admitted to the ICU required mechanical ventilation, in comparison to 39% in the international study and 47% in the study done in Scandinavia. This shows that the ICUs in Polish hospitals have high device utilization (DU) for mechanical ventilation, probably because of the small proportion of ICU beds in the hospital. The ventilated population of Polish ICU patients resembled other populations studied in terms of age and sex. In Polish hospitals, coma (usually after cardiac arrest) was more often (40%) the indication for mechanical ventilation than the international (15%) or the Scandinavian study (15%). This may be due to the limited availability of long-term mechanical ventilation facilities in the hospital other than the ICUs. In Poland, many patients had a tracheotomy (41%), which was higher than in the international (24%) and the Scandinavian study (32%).

The reason most often given for acute respiratory failure was postoperative respiratory insufficiency and pneumonia. The diagnosis of ARDS was reported only for 4% of ventilated patients in the Polish study, in comparison with 12% of cases in the international study and 5% of cases in the Scandinavian study. This low rate may be associated with a lack of experience in diagnosing this syndrome [12]. University hospitals were better

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Table 4. A comparison of the results of point-prevalence epidemiological studies on mechanical ventilation in ICUs.

	International study 2000 [4]	Scandinavian study 2002 [5]	Polish study 2010
The number of ventilated patients (% of total ICU patients)	1638 (36%)	108 (47%)	327 (74%)
Age [years]*	61	66	63
Gender (% men)	60	69	63
Indications for ventilation: (%)			
ARF	66	73	40
Coma	15	15	40
COPD	13	8	15
Neuromuscular disease	5	4	5
Mechanical ventilation modes:			
Tidal volume (ml/kg) *	9	7	8
Peak inspiratory pressure (cmH_2O) *	18	22	21
Respiratory rate (breath/min) *	16	17	13
PEEP value (cmH_2O) *	5	6	5
% of ventilation with PEEP	69	99	81
% of patients with tracheostomy	24	32	41

* Median value. ARF – acute respiratory failure; COPD – chronic obstructive pulmonary disease; PEEP – positive end-expiratory pressure.

equipped to diagnose ARDS in ventilated patients. The actual number of patients with ARDS was probably higher, but this study was not designed to analyze precisely the incidence of ALI or ARDS, similar to other prospective cohort studies [13–16].

The mode of ventilation varied in comparison to the Scandinavian study, probably due to the uniform availability of equipment in Scandinavian countries, which is not the case in Poland. The predominant modes of ventilation used on more than half the patients were those that took into account the patient's own breathing effort, such as SIMV or PS. The mean breathing volume of 8 mL/kg was similar to that used in the international study (9 mL/kg) and the Scandinavian study (7 mL/kg). The tidal volumes used were higher than recommended for the treatment of ARDS, but only 4% of patients had been diagnosed with ARDS. A lung-protective strategy of ventilation should also be used in other types of acute respiratory failure [17]; therefore, the current model of ventilation in ICUs should be modified. The peak inspiratory pressure was similar among studies. The concentration of inhaled oxygen was the same as in the Scandinavian study (40%).

The PEEP value in the Polish study (5 cmH_2O) was comparable to the international (5 cmH_2O) and the Scandinavian (6 cmH_2O). The frequency of using PEEP (81%) was higher than in the international study (69%), but lower than in the Scandinavian countries (99%).

A weakness of our study is the point-prevalence model. One-day cross-sectional studies have several shortcomings, one of the biggest being the lack of information on the medical outcome of ventilated patients, and their morbidity and mortality rates. A decidedly better research method is a prospective study design [7–9]. However, the results presented here, as the first epidemiological assessment of mechanical ventilation in Poland, allow for a preliminary analysis and serve as the first step of planned, prospective research on patients treated with mechanical ventilation. Prospective observational studies are needed to assess the clinical course and prognosis of mechanically ventilated patients.

Based on the results of our study, we established a program for continuous education on mechanical ventilation for intensivists. Over the past 3 years we have annually organized a "Winter School of Ventilation" with active hands-on training in a designated education centre. In 2015 we plan to do a new survey to see how the models and techniques of ventilation will have evolved in the subsequent 5 years.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Conclusions

We have shown that mechanical ventilation is the method most commonly used in ICUs in Poland. Almost half of the ventilated patients in the ICUs were ventilated for extrapulmonary indications (central nervous system and neuromuscular diseases). Patients were ventilated with low concentrations of oxygen, and PEEP was commonly used.

Conflict of Interest

All authors declare no conflict of interest.

References:

1. Kacmarek RM: The mechanical ventilator: past, present, and future. Respir Care, 2011; 56: 1170–80
2. de Prost N, Ricard JD, Saumon G, Dreyfuss D: Ventilator-induced lung injury: historical perspectives and clinical implications. Ann Intensive Care, 2011; 1: 28
3. Esteban A, Alía I, Ibañez J et al: Modes of mechanical ventilation and weaning. A national survey of Spanish hospitals. Chest, 1994; 106: 1188–93
4. Esteban A, Anzueto A, Alía I et al: How is ventilation employed in the intensive care unit. An international utilization review. Am J Resp Crit Care Med, 2000; 161: 1450–58
5. Kárason S, Antonsen K, Aneman A; SSAI ICU-II GROUP: Ventilator treatment in the Nordic countries. A multicenter survey. Acta Anaesthesiol Scand, 2002; 46: 1053–61
6. Wunsch H, Linde-Zwirble WT, Angus DC et al: The epidemiology of mechanical ventilation use in the United States. Crit Care Med, 2010; 38: 1947–53
7. Esteban A, Anzueto A, Frutos F et al: Characteristics and outcomes in adult patients receiving mechanical ventilation. A 28-day interventional study. JAMA, 2002; 287: 345–55
8. Esteban A, Ferguson ND, Meade MO et al: Evolution of mechanical ventilation in response to clinical research. Am J Respir Crit Care Med, 2008; 177: 170–77
9. Metnitz PG, Metnitz B, Moreno RP et al: Epidemiology of mechanical ventilation: analysis of the SAPS 3 database. Intensive Care Med, 2009; 35: 816–25
10. Frutos-Vivar F, Ferguson ND, Esteban A: Mechanical ventilation: quo vadis? Intensive Care Med, 2009; 35: 775–78
11. Goligher E, Ferguson ND: Mechanical ventilation: epidemiological insights into current practices. Curr Opin Crit Care, 2009; 15: 44–51
12. Ferguson ND, Frutos-Vivar F, Esteban A et al: Acute respiratory distress syndrome: underrecognition by clinicians and diagnostic accuracy of three clinical definitions. Crit Care Med, 2005; 33: 2228–34
13. Luhr OR, Antonsen K, Karlsson M et al: Incidence and mortality after acute respiratory failure and acute respiratory distress syndrome in Sweden, Denmark, and Iceland. The ARF Study Group. Am J Respir Crit Care Med, 1999; 159: 1849–61
14. Rubenfeld GD, Caldwell E, Peabody E et al: Incidence and outcomes of acute lung injury. N Engl J Med, 2005; 353: 1685–93
15. Linko R, Okkonen M, Pettilä V et al: Acute respiratory failure in intensive care units. FINNALI: a prospective cohort study. Intensive Care Med, 2009; 35: 1352–61
16. Villar J, Blanco J, Añón JM et al: The ALIEN study: incidence and outcome of acute respiratory distress syndrome in the era of lung protective ventilation. Intensive Care Med, 2011; 37: 1932–41
17. Schultz M: Lung-protective mechanical ventilation with lower tidal volumes in patients not suffering from acute lung injury: A review of clinical studies. Med Sci Monit, 2008; 14(2): 22–26

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]