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Ventilator-associated events prevention, learning lessons from the past: A systematic review

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ABSTRACT

Background: Preventing Ventilator-associated events (VAE) is a major challenge. Strictly monitoring for ventilator-associated pneumonia (VAP) is not sufficient to ensure positive outcomes. Therefore, the surveillance definition was updated and a change to the broader VAE was advocated.
Objective: This paper summarizes the scientific efforts assessing VAP preventive bundles and the recent transition in surveillance methods.
Methods: We conducted a systematic review to identify lessons from past clinical studies assessing VAP prevention bundles. We then performed a thorough literature review on the recent VAE surveillance algorithm, highlighting its advantages and limitations.
Conclusion: VAP prevention bundles have historically proven their efficacy and the introduction of the new VAE definition aimed at refining and objectivizing surveillance methods. Randomized controlled trials remain vital to determine the effect of VAE prevention on patient outcomes. We recommend expanding beyond limited VAP prevention strategies towards VAE prevention bundles.

Introduction

Ventilator-associated pneumonia (VAP) is prominent in intensive care units worldwide. In the United States, VAP accounts for approximately 300,000 cases of ICU acquired infections per year.[1] VAP is not only the most common hospital-acquired infection in ICUs, it is also associated with increased mortality, morbidity, and economical burden on the health care system.[2–8]

The impact of VAP on mortality has always been controversial due to limitations in most of the previous studies. Small sample sizes, inability to perform relevant subgroup analyses and the presence of several confounding factors, have hampered a reliable measurement of VAP-attributable mortality rates. In the literature, a wide range of estimates was reported for VAP-attributable mortality rates ranging between 20 and 55%. A recent meta-analysis, published by Melhsen et al (2013) used original individual patient data from published randomized trials on VAP prevention. With a total sample size of 6284 patients from 24 trials, the reported overall VAP-attributable mortality was 13%.[9]

Acquiring VAP is also associated with increased ICU length of stay (LOS). In fact, studies have shown an increase in ICU LOS ranging from 4.3 to 13 days, with an average of a 6-day increase attributable to VAP.[10–13] This ultimately led to increasing the cost of each hospital admission associated with a diagnosis of VAP by more than $40,000.[14–16] VAP is the hospital acquired infection with the highest economic impact per episode. With an added cost per episode of more than twice that of a central line-associated bloodstream infection and ten times that of an episode of catheter-associated urinary tract or Clostridium Difficile infection.[17]

During the first week of mechanical ventilation, patients are at highest risk of acquiring VAP with risk rates of approximately 3% per day.[18]

A potentially growing burden of VAP is to be anticipated in the future, as a consequence of population aging.[19] Furthermore, an

Abbreviations: VAE, ventilator-associated events; ICU, intensive care unit; VAP, ventilator-associated pneumonia; CDC, centers for disease control; LOS, length of stay; IHI, Institute of Healthcare Improvement; HOB, head of bed; PUD, peptic ulcer disease; DVT, deep vein thrombosis; CINAHL, Cumulative Index to Nursing and Allied Health; IVAC, infection-related ventilator-associated complications; NHSN, National Healthcare Safety Network; PEEP, positive end-expiratory pressure; FIO_2, fraction of inspired oxygen; ATS, American Thoracic Society; IDSA, Infectious Diseases Society of America.

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increase in bacterial resistance is expected as a result of the rise in antimicrobial prescription accompanying VAP.[20,21] Considering all the aforementioned reasons, VAP prevention in mechanically ventilated patients must be regarded as a critical mission. Therefore, a vital need arises to establish a multi-dimensional strategy for VAP prevention. The components of such strategy would combine continuous staff education, VAP prevention bundles and effective surveillance. VAP preventive measures are numerous and some remain controversial.[5,17]

This manuscript will provide a two-faceted overview on the preventive efforts aiming to improve the quality and safety of the mechanically ventilated population over the last decade. First, we will provide a summary of the studies that incorporated VAP preventive bundles and evaluated their effect on patient outcomes. To this purpose, we will present the results and highlight the most important lessons learned from these past preventive efforts. Second, we will dissect the recently defined 2013 Ventilator-associated Event (VAE) surveillance innovative algorithm and its effects on the way we have historically tried to handle VAP detection and prevention. A thorough review of the most recent literature will be presented to describe the development of the new surveillance definition. This manuscript will culminate by evaluating the current gaps and the possible opportunities for improvement in ventilated patients' outcomes.

History of bundling

Health care providers have at their disposal an arsenal of tools to prevent VAP, including (a) VAP prevention bundles, (b) health care providers' education and (c) surveillance programs. These components are seldom organized into one strategic quality and patient safety improvement plan. Usually, bundled preventive measures are the cornerstone of every promising preventive strategy.

The concept of bundling in medicine dates back to the day of the northern plains Indians. At that time, Indian medicine bundles composed of a multitude of herbs and other elements that were believed to provide their carrier with the needed strength to prevent disease.[22] Nowadays, modern medicine defines bundles as the implementation of various grouped measures which when combined together achieve better outcomes than individually implemented interventions.

In order to capture the entirety of the past literature on VAP prevention bundles and their impact on ventilated patients' outcomes, we conducted a systematic review of relevant databases. The adopted process is described in the following paragraphs.

Methods: search strategy and data extraction

We performed a systematic search on Ovid MEDLINE, PubMed, and CINAHL for original studies examining the clinical outcome of VAP prevention bundle practice on mechanically ventilated patients. The search was limited to English language articles, published from January 2005 to January 2014. The choice of this timeframe was intended to retrieve articles subsequent to the "save a 100,000 lives campaign" launched by the Institute of Healthcare improvement (IHI) and which was the first to introduce the concept of VAP bundling. The subject headings "Pneumonia, Ventilator-associated" and "Prevention" were entered and explored to retrieve an extensive research resource for review. After removing duplicates, a preliminary screening of the resource list was conducted using the title and/or abstract to identify relevant studies that reported or evaluated the implementation of VAP preventive measures. Additionally, in order to ensure comprehensiveness, the reference lists of identified articles were checked further for related published materials. Two reviewers (J.C. and A.S.) independently assessed each of the selected studies for eligibility following an unblinded standardized manner. The selection criteria were based on exposure, outcome, population and methodology. Excluded studies did not measure "preventive bundling" as exposure and "VAP rates or mortality rates" as primary outcome. On the other hand, included papers adopted a cohort, prospective, or pre-post observational study design and targeted adult ventilated patients. As such, abstracts, letters to the editor, case reports, reviews, and original studies with less than 20 subjects were excluded. A final list of 22 studies was compiled and included in the systematic review. Fig. 1 is a diagram illustrating the adopted selection process of articles.

Data were retrieved by one reviewer (J.C.) and checked for accuracy and completeness by the second reviewer (A.S.), any disagreements were discussed and resolved to reach consensus. The extracted data consisted of three categories; (1) general study information: last name of first author, year of publication, location, scope (single or multicenter), study design, and sample size (number of subjects enrolled or alternatively number of ventilator-days included and cohort size); (2) exposure information: number and type of preventive measures included in the bundle; (3) outcome information (whenever applicable): pre- and post-intervention VAP rates, percentage change in VAP rates post-intervention, mortality rates, hospital LOS, ICU LOS, number of days on ventilator and/or compliance rates with the VAP bundle.

Results

Review of selected original studies

Extracted data from the 22 reviewed articles are summarized in Table 1.[23–44] All articles were published after 2004, the year IHI had

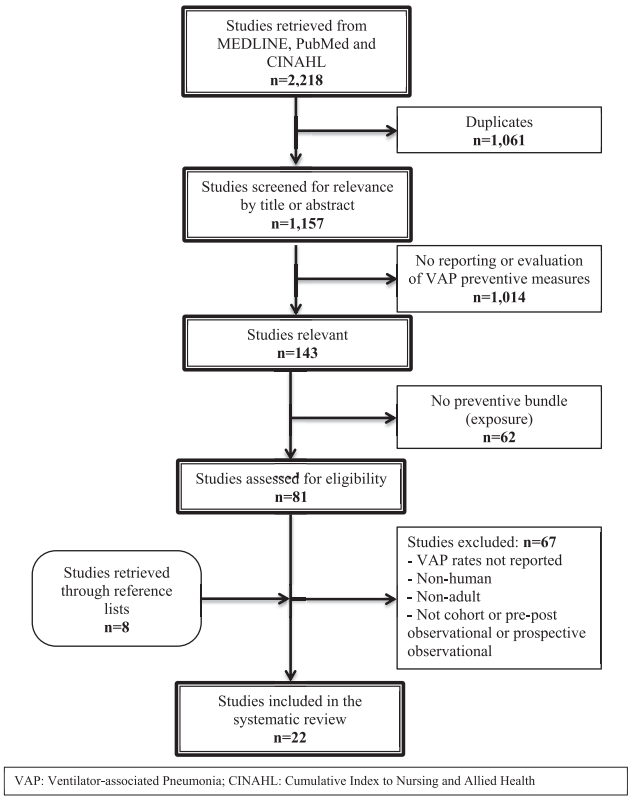

Fig. 1. Strategic search of studies on VAP prevention bundles. This diagram explains the selection process of articles while highlighting the inclusion/exclusion criteria.