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BRIEF REPORT

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# Does invasive diagnosis of nosocomial pneumonia during off-hours delay treatment?

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**Abstract** *Objective:* We examined whether invasive lung-specimen collection-to-treatment times for intensive care unit patients with suspected ventilator-associated pneumonia (VAP) differ with to the work shift during which specimens were collected. We compared weekday day shifts and off-hours (from 6:30 p.m. to 8:29 a.m. the next day for night shifts, from Saturday 1:00 p.m. to Monday 8:29 a.m. for weekends, and from 8:30 a.m. to 8:29 a.m. the following morning for public holidays). *Design and setting:* Single-center, observational study in the intensive care unit in an academic teaching hospital. *Patients and participants:* 101 patients who developed 152 episodes of bacteriologically confirmed VAP. *Measurements and results:* Of the 152 VAP episodes 66 were diagnosed during off-hours. Neither more bronchoscopy complications nor more inappropriate initial antimicrobial treatments for patients were observed between day and off-hour shifts. Indeed, the overall time from brochoalveolar lavage to antibiotic administration was shorter for off-hours than day-shifts due to shorter specimen collection-to-antibiotic prescription times, but antibiotic prescription-to-administration times were the same. *Conclusions:* An invasive strategy based on bronchoscopy to diagnose VAP was not associated with a longer time to first appropriate antibiotic administration when clinical suspicion of VAP occurs during off-hours.

**Keywords** Ventilator-associated pneumonia · Antibiotics · Appropriate treatment · Off-hours · Bronchoalveolar lavage · Invasive strategy

## Introduction

An invasive strategy for the diagnosis of ventilator-associated pneumonia (VAP) consists of immediately performing bronchoscopy (day 1) to sample distal pulmonary secretions in the area radiologically suspected of being infected, using bronchoalveolar lavage (BAL), with light microscopy examination of the cells collected in BAL fluid, looking for intracellular bacteria [1, 2]. One potential caveat of this strategy is that when clinical deterioration occurs during evening, night, weekend, or holiday shifts (referred to here as "off-hours", unless otherwise specified), this strategy may be more difficult to implement because of lower medical staffing level and less availability of such procedures during off-hours [3]. Moreover, it is well known that delayed appropriate antibiotic treatment for patients with VAP can be associated with a poorer prognosis [4, 5]. Because the intensive care unit (ICU) staffing level is often lower during off-hours, we hypothesized that the mean time from initially meeting the diagnostic criteria for VAP using the invasive strategy until administration of antimicrobial treatment would be longer during off-hours than during weekday day shifts.

We conducted this study to compare the mean times from bronchoscopy and BAL specimen collection to appropriate antimicrobial treatment administration for patients with microbiologically confirmed VAP, when clinical suspicion occurred during off-hour or day shifts.

## Materials and methods

The study took place in an 18-bed medical ICU of a teaching hospital, which functions as a "closed" ICU. A total of 650 patients were admitted to this ICU between January 2004 and April 2005, 312 of whom underwent mechanical ventilation (MV). The study population consisted of the 221 who were ventilated for 48 h or longer (Fig. E2, Electronic Supplementary Material, ESM). All those clinically suspected of having VAP underwent bronchoscopy and BAL fluid collection. VAP was diagnosed when all the following criteria were met: (a) clinical suspicion of VAP, defined as a new and persistent pulmonary infiltrate on chest radiograph associated with at least one of the following: temperature 38 °C or higher, white blood cell (WBC) count $10 \times 10^9$/l, and purulent tracheal secretions (in patients with acute respiratory distress syndrome, for whom the demonstration of radiological deterioration was difficult, at least one of the three preceding criteria sufficed); (b) significant growth ($\geq 10^4$ cfu/ml) of quantitative cultures of distal BAL fluid samples obtained by fiberoptic bronchoscopy [2]. The clinical characteristics at ICU admission of patients who developed VAP are reported in the ESM.

Sixty-six (43%) VAP episodes were diagnosed during off-hours. In France day shifts are defined by law as Monday to Friday, 8:30 a.m. to 6:29 p.m., and Saturday from 8:30 a.m. to 12:59 p.m.; and off-hours from 6:30 p.m. to 8:29 a.m. the next day for night shifts, from Saturday 1:00 p.m. to Monday 8:29 a.m. for weekends, and from 8:30 a.m. to 8:29 a.m. the following morning for public holidays [6]. During off-hours, one intensivist (board certified or in training-to-be) is on-call onsite, with a medical resident and a medical student. French law mandates that the physician in charge of the ICU during off-hours be either board-certified in critical care or in training-to-be, but in the latter case he/she must have completed at least 52 onsite night shifts as a resident in an ICU before being authorized to run the ICU during off-hours.

When a patient was suspected of having VAP, at any time and day, the attending physician immediately performed bronchoscopy and BAL [2]. All physicians working in our ICU, board-certified or in-training-to-be, were specifically trained to perform Diff-Quick staining and microscopy examination of BAL fluids [1]. Initial antibiotic prescription was guided by an algorithm, as described in the ESM [7, 8, 9, 10]. The protocol was in accordance with the ethical standards of our hospital's Committee for the Protection of Human Subjects. Informed consent was not obtained because this study did not modify existing diagnostic or therapeutic strategies.

Data are presented as median and range or absolute number and percentage. Values were compared as follows: continuous variables with the Mann–Whitney *U*-test or Student's *t*-test, as appropriate; categorical variables with the $\chi^2$ square test. Analyses were performed using StatView 5.0 (SAS, Cary, N.C., USA) software. Statistical significance was defined as $p < 0.05$. Additional details on the methods are available in the ESM.

**Table 1** Clinical characteristics and outcomes of the 152 VAP episodes as a function of the shift during which they were suspected; values are median (range) or absolute number (percentage) (*VAP* ventilator-associated pneumonia, *BAL* bronchoalveolar lavage, *AT* antimicrobial treatment, *MV* mechanical ventilation, *WBC* white blood cells, *SOFA* sepsis related organ failure assessment, *mCPIS* modified clinical pulmonary infection score as defined by Luyt et al. [15])

| | Day-shift episodes ($n = 86$) | Off-hours episodes ($n = 66$) | *p* |
|---|---|---|---|
| AT 15 days before VAP | 63 (73%) | 39 (59%) | 0.08 |
| MV duration before VAP onset (days) | 9 (2–132) | 6 (2–150) | 0.29 |
| Day1 | | | |
| Temperature (°C) | 38.3 (32.0–40.3) | 38.5 (34.2–41.7) | 0.18 |
| WBC count ($\times 10^9$/l) | 12.8 (0.5–36.5) | 12.2 (0.4–49.8) | 0.36 |
| Radiology score | 4 (0–12) | 4 (0–12) | 0.35 |
| $PaO_2/FIO_2$ratio | 203 (50–510) | 180 (51–500) | 0.10 |
| Day 1 mCPIS | 6 (2–10) | 6 (3–10) | 0.21 |
| Day 3 mCPIS | 8 (4–12) | 8 (5–12) | 0.48 |
| Day 1 SOFA score | 7 (0–19) | 7 (0–18) | 0.86 |
| Day 3 SOFA score | 7 (0–20) | 7 (0–18) | 0.90 |
| Complications of bronchoscopy | | | |
| Oxygen desaturation | 2 (2%) | 1 (2%) | 0.85 |
| Pneumothorax | 0 | 0 | – |
| Bronchial bleeding | 0 | 0 | – |
| Death within 24 h after VAP onset | 3 (3%) | 1 (2%) | 0.85 |
| Time from BAL to AT prescription (min) | 103 (5–620) | 70 (15–240) | 0.004 |
| Time from AT prescription to administration (min) | 15 (0–150) | 15 (0–75) | 0.83 |
| Time from BAL to AT administration (min) | 135 (15–670) | 93 (15–270) | 0.005 |
| Initial inappropriate AT | 6 (7%) | 5 (8%) | 0.99 |

## Results

Clinical deterioration requiring bronchoscopy (day 1) and BAL was found to be the same for all shifts. Patients' outcomes are presented in Table 1. Neither more bronchoscopy complications nor less appropriate initial antimicrobial treatments for patients were observed between day and off-hour shifts. The period between BAL collection and antibiotic administration was significantly shorter when specimens were collected during off-hours ($p = 0.005$). This difference was due to a significantly longer period between BAL collection and antibiotic prescription in patients whose bronchoscopy was performed during day shifts ($p = 0.004$), but the time from antibiotic prescription to antibiotic administration was not affected by the hour of prescription.

## Discussion

According to our results, almost one-half of VAP episodes were diagnosed during off-hours, when the medical staffing level was lower. Most of these off-hour episodes were diagnosed during weekend shifts, and only 19 episodes occurred during night shifts. Surprisingly, and in contrast to our hypothesis, we found that the time from BAL collection to antibiotic administration was longer for episodes diagnosed during day shifts than during off-hours. This difference was not due to delayed antibiotic administration during day shifts because the period from antibiotic prescription to administration was the same in both groups but rather to a longer time from BAL specimen collection to antibiotic prescription by the day-shift physician-in-charge. Lastly, only a low proportion of patients received initial inappropriate antimicrobial treatment, regardless of the specimen collection shift.

To our knowledge, this is the first study to evaluate whether the use of an invasive strategy to diagnose VAP delays appropriate antibiotic administration, when the diagnosis is made during off-hours. Iregui et al. [4] evaluated 107 patients with VAP who had received an antibiotic regimen that was shown to be active in vitro against the pathogens isolated from their respiratory secretions; antibiotic administration was delayed for at least 24 h in 33 of their patients, mainly because of delays in writing antibiotic orders (25/33). The authors hypothesized that the cause was failure of attending physicians to recognize VAP, forgetting to write orders for antibiotics, awaiting the results of diagnostic tests such as cultures, or attributing the patient's clinical findings to a noninfectious process [4]. However, they did not examine whether the shift during which clinical suspicion occurred had the effect of delaying antibiotic prescription. Our study observed no delay in the administration of antibiotics during off-hours, and indeed the time to antibiotic administration was shorter. Unfortunately, our study was not designed to assess factors that may explain why patients received antibiotics earlier.

Several possible explanations of our surprising observations can be envisaged. The predominantly diurnal organization of our ICU may at least partly explain the long period from BAL specimen collection to antimicrobial treatment prescription. During day shifts physicians have other responsibilities in addition to taking care of patients (e.g., staff meetings; secretarial, administrative and teaching responsibilities; interactions with patients' families) that may interfere with patient management and indirectly impinge on the quality of care. During off-hours the in-charge physician is not distracted by these obligations and is thus able to concentrate exclusively on patients with specific problems. Pertinently, we and other investigators have demonstrated that mortality in patients admitted during off-hours is not higher than in those admitted during day shifts, consistent with a constant level of care, regardless of the time and day [6, 11, 12, 13].

Our study has several limitations. First, this was a single-center study, with trained physicians who are able to perform bronchoscopy, BAL, and microscopy examination of the BAL fluids. Hence it is difficult to extrapolate our results to other ICU with different organizations and levels of technical expertise required of their medical teams. Several technical factors, including the need to have adequate resources (e.g., someone to perform the bronchoscopy and a microbiologist to examine the specimens rapidly) may render difficult the implementation of these procedures in many hospitals and may limit their widespread use [14]. However, all of our ICU physicians, including the least experienced, were mastered the various procedures used in the invasive strategy after a relatively short learning period. Secondly, a potential caveat of the invasive strategy is that when clinical deterioration occurs during off-hours, fiberoptic bronchoscopy may be less available and thus delayed, as well as antimicrobial treatment. Our study was unable to determine the precise duration from the time when clinical criteria of suspected VAP were fulfilled and the performance of bronchoscopy. Although it is unlikely that this period differed during off-hour and day shifts, we cannot exclude such a possibility. Third, the times of bronchoscopy, antibiotic prescription, and administration were entered manually by the nurses in charge of the patients into our electronic case report form (Clinisoft, General Electric) and may have included coding errors.

In conclusion, we found that an invasive strategy based on bronchoscopy to diagnose VAP did not delay appropriate antibiotic administration when clinical suspicion of VAP occurs during off-hours. The period to antibiotic administration was even shorter when BAL fluid collection was performed during off-hour than day shifts. Whether these findings have an impact on outcome remains to be determined.

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