Étude analytique rétrospective des pneumopathies à *Staphylococcus aureus* sécréteur de la leucocidine de Pantón-Valentine sur l'île de La Réunion

Retrospective study of pneumonia due to Pantón-Valentine leukocidin-producing *Staphylococcus aureus* in Reunion

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Résumé

Objectif. La pneumonie nécrosante à *Staphylococcus aureus* sécréteur de leucocidine de Panton-Valentine est rare, mais caractérisée par un taux de mortalité élevé. Cette pathologie touche essentiellement le sujet jeune, sans antécédent, et est généralement précédée d'un épisode grippal.

Méthodes. Analyser les cas de pneumopathies nécrosantes à *Staphylococcus aureus* sécréteur de leucocidine de Panton-Valentine, rencontrés dans les centres hospitaliers de La Réunion et admis par un service d'urgence. Nous avons réalisé une étude rétrospective effectuée sur le recueil de données des dossiers médicaux et des registres de laboratoire des patients hospitalisés pour une pneumopathie nécrosante à *Staphylococcus aureus* sécréteur de leucocidine de Panton-Valentine entre décembre 2014 et décembre 2017.

Résultats. En trois ans, 16 patients ont été sélectionnés, avec une médiane d'âge de 40,5 ans. Plus de la moitié des patients avaient été admis au préalable dans le service des urgences pour un syndrome de détresse respiratoire aigu ou un sepsis sévère. Quatorze patients ont été hospitalisés en service de réanimation, et six sont décédés dont cinq précocement.

Conclusion. L'évolution rapide et souvent fatale de cette pneumopathie oblige le praticien à ne pas méconnaître cette infection, surtout en saison grippale et à insister sur la prescription d'une antibiothérapie adaptée, comprenant un anti-infectieux anti-toxinique dès la suspicion de la pathologie dans le service des urgences. Toutefois, la rareté du SARM à la Réunion, nous permet encore d'adapter l'antibiothérapie probabiliste en urgence au contexte local, sans l'introduction obligatoire de glycopeptides.

Abstract

Objective. Panton-Valentine leukocidin-producing *Staphylococcus aureus* necrotizing pneumonia is an unusual cause of community-acquired pneumonia, although associated with a high case fatality. This infection mainly affects young individuals, without any history, and is most often preceded by flu-like symptoms.

Method. We focused on patients presenting with *Staphylococcus aureus* necrotizing pneumonia in Reunion (Indian Ocean) admitted to the emergency department. We performed a retrospective study based on data collected from laboratory registers and medical files of patients presenting with *Staphylococcus aureus* necrotizing pneumonia in Reunion between December 2014 and December 2017.

Results. A total of 16 patients were recruited for this study, with a median age of 40.5 years. More than half of patients had previously been admitted to the emergency department for acute respiratory distress syndrome or severe sepsis. Fourteen patients were admitted to the intensive care unit and six patients died (five premature deaths).

Conclusion. Physicians should be aware of this infection during the flu season and quickly adapt the specific antibiotic treatment, including a drug inhibiting toxin production. As methicillin-resistant *Staphylococcus aureus* is very rarely observed in Reunion, physicians can still adapt the empirical treatment, without glycopeptides.

During the flu season in Reunion, a French overseas department located in the Indian Ocean, lung superinfections are a frequent reason for medical consultations in emergency departments. Staphylococcal necrotizing pneumonia is rare, but may be particularly severe and sometimes lethal, when the infectious agent has the gene encoding for Panton-Valentine leukocidin (PVL). This toxin forms pores on the cell membranes of neutrophils, monocytes, and macrophages and activates neutrophils with the release of superoxide ions and lytic enzymes [1]. Particular attention should be paid to the diagnostic and treatment process as soon as patients are admitted because of the potential severity of this infection. Absent from Reunion a few years ago, or perhaps less frequently considered, an increasing number of reports establish its emergence in this ultramarine department. No standardized treatment is currently available for the management of PVL+ *Staphylococcus aureus* (*S. aureus*) necrotizing pneumonia. However, recommendations based on *in vitro* studies, clinical case analysis, and strategies have been issued for the management of toxic diseases [2,3]. This etiological management is mainly based on appropriate antibiotic therapy, limiting toxin production and immunotherapy.

The main objective of the study was to analyze the characteristics of cases of Panton-Valentine leukocidin-producing *Staphylococcus aureus* pneumonia in Reunion. The secondary objectives were to establish diagnostic and prognostic factors at admission to the emergency department.

PATIENTS AND METHODS

This retrospective and observational study was performed over a three-year period, from December 1, 2014 to December 1, 2017. The study included patients admitted to the emergency department for pneumonia or acute respiratory syndrome with a positive

bacteriological sample for *S. aureus*, a Panton-Valentine leukocidin-producer. Patient recruitment, epidemiological/clinical/biological data, qSOFA score [4], imaging results, treatments, and patient outcomes were obtained from computerized records saved on the medical software of each hospital. The biological diagnosis of PVL+ *S. aureus* infection was based on microbiological results from either the National *Staphylococcus* Reference Center (French acronym CNR) or a multiplex PCR technique encoding for the *S. aureus* Panton-Valentine leukocidin gene at the local microbiology laboratory. An antimicrobial susceptibility test was always performed to complement results. Exclusion criteria were patients repatriated from the sub-region for medical reasons prior to hospitalization, patients presenting with healthcare-associated infections, and patients not previously admitted to the emergency department. This retrospective and non-interventional study does not fall within the scope of the regulations governing research involving humans within the meaning of articles L1121-1-1 and L1121-3. The study was declared to the French Data Protection Authority (French acronym CNIL): number 2170141v0. Results are expressed as the number of patients (percentage of patients) or median (Quartile 1-Quartile 3). No statistical test was performed.

RESULTS

Between December 1, 2014 and December 1, 2017, 17 patients were hospitalized for PVL+ *S. aureus* lung infection and 16 were included in the study. One patient met the exclusion criteria. The sex ratio was 2.2 (11 males/5 females). The median age was 40.5 years (2 months-82 years). Five patients (29.4%) were under 15 years of age, including three infants under one year of age, eight (47%) were between 16 and 50 years of age, and three (23.6%) were over 51 years of age. With regards to reasons for admission to the emergency

department, 12 patients presented with signs of febrile respiratory distress syndrome or severe sepsis, one patient was admitted for suspected leptospirosis, three patients had a rapid change in isolated febrile general state or associated with acute renal failure, or digestive signs. Hemoptysis was reported in the admission file of four patients. Five patients had major history or comorbidities: heart disease (73 y/o), chronic kidney failure with type 1 diabetes (46 y/o), prostate cancer (82 y/o), kidney transplantation (19 y/o), neurological compression syndrome (50 y/o). Eleven patients had no history or significant comorbidity (69%). Nine patients (56%) reported influenza-like illness in the days before respiratory tract infection.

A quick sequential organ failure assessment (qSOFA) was performed in 12 patients (four patients were children under two years of age), allowing rapid evaluation of sepsis criteria with a predictive value of mortality and therefore eligibility for admission to the intensive care units (ICU). The qSOFA score was ≥ 2 in seven patients and < 2 in five patients.

Paraclinical examinations

All patients had at least one positive PVL+ *S. aureus* sample (10 blood cultures, six cytobacteriological examinations of sputum, three bronchoalveolar lavages, two pleural samples, one nasal sample performed). Of these samples, only one was positive for PVL+ methicillin-resistant *S. aureus* (MRSA) (nasal sample from a patient who had stayed in Mayotte) versus 15 patients with PVL+ methicillin-susceptible *S. aureus* (MSSA). Out of 16 patients, 10 samples were positive for PVL+ *S. aureus* according to the CNR analyses. Among them, a gene encoding for agr1 allele (four patients), agr2 allele (one patient), and agr3 allele (three patients) was identified, and no precision was found in the files for two patients. For the remaining six patients, examinations were performed locally by multiplex PCR. Regarding results of the antimicrobial susceptibility tests, all strains were resistant to

penicillin G; two strains were resistant to co-trimoxazole, one to fusidic acid, and one to amoxicillin and cefotaxime. Only one case of MRSA was reported. Three patients had leukopenia <3 G/L and six >10 G/L. Five patients had thrombocytopenia (<150 G/mm³), two of whom had $<100,000$ platelets/mm³. Among the markers of inflammation, only eight C-reactive protein (CRP) and eight procalcitonin (PCT) test results were collected. Among them, there were two CRP ≥ 300 mg/ml and eight positive PCT assays ≥ 0.5 ng/ml.

The pulmonary radiography, often associated with computed tomography, performed in 16 patients revealed eight unilobar pneumonias, three bilateral pneumonias, a bilateral alveolar syndrome, four disseminated nodules excavated bilaterally or of abscesses, and four pleural effusions.

Management and treatment

The antibiotic therapy was initiated in the emergency department for 14 patients. Eleven patients received a first-line broad-spectrum antibiotic therapy: amoxicillin 1 g three times daily (one patient presenting with suspected leptospirosis), ceftriaxone 2 g daily (two patients), cefotaxime 2 g every 8 hours or 150 mg/kg/day (five patients), piperacillin-tazobactam 16 g daily (one patient) or intravenous ciprofloxacin 400 mg/12 hours (one patient presenting with infectious diarrhea). The antibiotic therapy was combined with an aminoglycoside (gentamicin 5 mg/kg or amikacin 20 mg/kg) for nine patients. Three patients received first-line anti-infective antistaphylococcal therapy (cloxacillin or oxacillin, 8 g per day for adults and 200 mg/kg/day for children) combined with a broad-spectrum antibiotic. Only three patients received an antitoxic antistaphylococcal agent at the emergency department (clindamycin 600 mg or 10 mg/kg/day for children or rifampicin 10 mg/kg twice daily).

Anti-infective treatments prescribed in the ICU or in medical wards were adequate in eight patients when using the combination with clindamycin (600 mg three times daily) or linezolid (600 mg twice daily). Two patients died rapidly, and two files had no treatment indication. One patient received a synergistin at a dose of 1 g three times daily.

Evolution

Fourteen of 16 patients were hospitalized in an ICU (87.5%): nine patients received invasive ventilation, two patients with no sign of severity were hospitalized in a pneumology unit. Six patients died (37.5%), five of them within 48 hours of admission to the ICU. Favorable outcome was observed in 10 patients (62.5%). Two patients received extracorporeal life support: one died within 48 hours (Table 1).

DISCUSSION

S. aureus is found in 2% to 5% of community-acquired pneumonia cases, more frequently in the elderly with comorbidities or in an influenza context. *S. aureus* may secrete a particular leukotoxin, i.e. PVL, responsible for severe necrotizing pneumonia, with a high case fatality (30% to 75%) [5-8]. PVL is an endotoxin secreted by some strains of *S. aureus*, observed in less than 5% of strains isolated in Europe [2-9]. It is responsible for a significant local inflammatory reaction and pulmonary epithelium lesions, progressing to necrosis [8]. In Europe the incidence of PVL+ *S. aureus* necrotizing pneumonia is low, although probably underestimated. Unlike in the United States where a significant increase in MRSA lung infections was observed, these infections are mostly caused by MSSA in metropolitan France and Reunion [10-11].

PVL+ *S. aureus* necrotizing pneumonia mainly affects children and young adults, most often presenting without any comorbidity [12-15]. An influenza syndrome preceding this rapidly

developing infection has been reported in nearly 75% of cases [2,16-18]. Our study confirms this data, with an average age of 34.2 years (median 40.5 years), including four children under two years of age. More than half of patients did not have any history of influenza syndrome prior to hospitalization.

The clinical presentation, reported by Gillet *et al.*, is characterized by the association of high fever ($>39^{\circ}\text{C}$), multilobar alveolar patterns, hemoptysis, and initial leukopenia [8,13]. This picture is frequently associated with rapid respiratory distress syndrome and hemodynamic instability. Generalized erythroderma is reported in 10% of cases. Standard biological tests usually reveal leukopenia ($<3 \text{ G/L}$), with a marked inflammatory syndrome and a very high CRP ($>300 \text{ mg/l}$), unlike leukopenia (Table 2) [6,8]. This typical clinical picture seems easily identifiable, but atypical or incomplete presentations are relatively frequent, and diagnosis is therefore more difficult to establish. Our work supports previously published results on the disease severity with 12 (75%) patients presenting with clinical signs of severe sepsis or acute respiratory distress syndrome (ARDS) on admission and 14 (87.5%) who required admission to the ICU [2,11]. More than a third of patients died, corroborating data from previous studies [5,7,8,13].

In addition to hemodynamic failure and the development of ARDS requiring rapid management in the ICU, the mortality predictors described by Gillet *et al.* are leukopenia, skin rash (signs of toxic damage), and hemoptysis [8]. Only 25% of patients in our series presented with hemoptysis. This incidence should be confirmed on more significant samples. Leukopenia was reported in only three patients. This low rate of leukopenia is probably due to the initial nature of leukopenia described in this condition, and to the late hospital admission of patients.

Just like leukopenia, CRP does not seem to guide diagnosis. In addition to its low specificity, values >300 mg/mL were only tested in two of eight samples. However, a procalcitonin value >0.5 ng/ml was observed in all available samples.

Radiological imaging often reveals bilateral alveolar infiltrates, multilobar patterns in approximately 80% of cases and associated with pleural effusions in 50% of cases. Unilobar patterns have been reported in less than 20% of cases [17] (Figure 1). Our study reported a rather eclectic imaging aspect, making diagnosis more complex, with unilobar and multilobar pneumonia and excavated or abscessed patterns. These lesions were associated with pleural effusion in less than a quarter of reported cases.

Twelve patients of our study were admitted to the emergency room with signs of severity (seven patients with qSOFA ≥ 2 and five children with severe sepsis), and 14 were promptly admitted to the ICU, confirming the rapidly serious progression of the disease. Three patients received an antitoxin antibiotic in the emergency department, suggesting the diagnostic hypothesis of PVL+ *S. aureus* infection.

PVL+ *S. aureus* bacterial infections are still uncommon in France and in the overseas departments of the Indian Ocean. It is thus relatively unknown to physicians. This usually leads to a delayed diagnosis, as it is rarely considered upon admission.

The very rapid nature of the poor outcome of this infection raises the issue of empirical antibiotic therapy when the infection is suspected as early as admission to the emergency department [19-21]. The antibiotic therapy is based on the combination of a bactericidal molecule with good pulmonary diffusion active against *Staphylococcus*, *S. pneumoniae*, and *S. pyogenes*, and an anti-infective agent reducing the production of toxins such as linezolid, clindamycin, or rifampicin [2]. Due to the retrospective nature of the study, we were only

able to collect 12 files mentioning antibiotic therapy administration in the wards. Among them, nearly 92% of patients had received a targeted two-drug antibiotic therapy with antitoxin action and only one patient had received a broader spectrum antibiotic monotherapy with favorable outcome. Despite early antibiotic therapy, six deaths were observed: five occurred within 48 hours of admission to the ICU. We must also insist on the complexity of the diagnosis of PVL+ *S. aureus* pneumonia, its rapid and severe nature, and its targeted and early management [22].

Given the emergence of methicillin-resistant staphylococcus strains (MRSA), current French protocols for the management of severe necrotizing pneumonia in adults recommend a three-drug empirical antibiotic therapy combining a glycopeptide, a 3rd-generation cephalosporin, and clindamycin or rifampicin [10,17]. However, MRSA is rarely observed in Reunion, with only one case reported in the patient from Mayotte. This specificity does not prompt physicians to introduce vancomycin as an empirical agent, except for patients returning from a high prevalence region for MRSA (East Africa, Comoros, Madagascar, Asia), or in a context of potential resistance [9,11].

In case of severe pneumonia in young patients, in a post-influenza context in Reunion, the possibility of PVL+ *S. aureus* should be taken into account for empirical treatment in addition to the usual pathogens. In the absence of contraindications, the empirical antibiotic therapy should consist in a broad-spectrum antibiotic therapy combined with clindamycin or linezolid in the emergency department. Treatment should then be adapted to microbiological results according to the susceptibility of the pathogen, combining an antistaphylococcal molecule and an antibiotic inhibiting toxic secretion. Treatment duration

remains controversial, ranging from three to eight weeks depending on clinical presentations [17,19].

Among potential adjuvant therapies, intravenous immunoglobulins could be of value for staphylococcal toxic shock syndrome [7]. They include antibodies directed against the two subunits of PVL and blocking the lytic action of PVL *in vitro* with a concentration-dependent action [24]. Although very few studies reported on the use of immunoglobulins, their early use would theoretically limit the worsening of parenchymal lesions. The suggested dosage is 1 g/kg/day for two days [25]. Some authors suggested using systematic immunoglobulins in case of toxic shock or in the presence of mortality risk factors (leukopenia <3G/L and/or hemoptysis) [17].

Limitations of our study are related to its retrospective nature, leading to missing data. The small sample size, due to the low prevalence of this pathology, also makes it difficult to interpret the results.

CONCLUSION

We reported cases of *S. aureus* infections secreting the toxin of Panton-Valentine, responsible for major pneumonia in Reunion. Despite our small sample size, our results corroborate data from previously published articles. Our data highlights the emergence of PVL+ *S. aureus* in this overseas territory. The early introduction, as soon as etiological suspicion is raised, of an anti-toxin antibiotic (clindamycin, linezolid, or rifampicin) combined with a 3rd-generation cephalosporin could improve the prognosis of this still unknown and potentially fatal infection. The rarity of MRSA in Reunion does not encourage physicians to immediately introduce vancomycin, as suggested in the current French guidelines, unless specific conditions apply.

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Figure 1. Radiographie pulmonaire (A) retrouvant une image de pneumopathie lobaire supérieure droite et scanner thoracique (B) avec un aspect d'image nécrosante

Figure 1. (A) Chest X-ray showing right upper lobar pneumonia. (B) Chest CT scan showing necrotizing pneumonia

Tableau 1. Présentation des patients hospitalisés pour une pneumopathie à *S. aureus* PVL+ dans les centres hospitaliers à la Réunion entre 2014 et 2017
Table 1. Characteristics of 16 patients admitted to the emergency department for PVL+ *Staphylococcus aureus* pneumonia in Reunion between 2014 and 2017

	N	%
Age (N=16)		
<15 y/o	5	31.25
16-50 y/o	8	50
>51 y/o	3	18.75
No comorbidity or medical history	11	68.75
Influenza-like infection prior to hospitalization	9	56.25
Causes for emergency department admission (N=16)		
- Respiratory distress or severe sepsis	9	56.25
- Fever with rapid alteration of the general status	6	37.5
- Suspicion of leptospirosis	1	6.25
Radiography and/or pulmonary CT scan (N=16)		
- Unilateral pneumonia	8	50
- Bilateral pneumonia	3	18.75
- Alveolar syndrome	1	6.25
- Excavated nodules or pulmonary abscesses	4	25
- Pleural effusion	4	25
Severity criteria		
- Hemoptysis (N=16)	4	25
- Leukopenia ($<3,000/\text{mm}^3$) (N=16)	3	18.75
- qSOFA ≥ 2 (N=12)	7	58.33
- qSOFA < 2	5	41.67
Number of admissions to the ICU	14	87.5
Number of admission to medical wards	2	12.5
Deceased patients	6	37.5
Favorable outcome	10	62.5

CT: computed tomography; ICU: intensive care unit

Tableau 2. Présentation clinique classique d'une pneumopathie nécrosante à *S. aureus* PVL+ **Table 2.** Typical clinical presentation of PVL+ *Staphylococcus aureus* necrotizing pneumonia

- Patient's characteristics
- - Child or young adult
- - Recent influenza episode

Clinical signs

- Dyspnea
- Hyperthermia >39°C
- Hemoptysis*
- Erythroderma*
- Acute respiratory distress syndrome (ARDS)*

Biology

- Initial leukopenia (leukocytes <3,000/ml)*
- Very high CRP (>300 mg/l)

Chest X-ray

- Multilobar alveolar infiltrates*
- Pleural effusion

Lung CT scan

Multilobar infiltration of the pulmonary parenchyma with cavities of variable size

Outcome

- Rapidly unfavorable (ARDS, septic shock)
- Significant case fatality (about 50%)

* Severity criteria and mortality factors according to Gillet *et al.* [8]