Skin diseases caused by Panton-Valentine leucocidin-producing *Staphylococcus aureus*: Profile and immunological follow-up of patients in a peri-urban area in Benin

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This study aims to highlight the role of Panton and Valentine Leucocidin (PVL) in *Staphylococcus aureus* isolated from skin diseases in the peri-urban area of Benin. This study, conducted from November 2014 to December 2017, include 124 wound, abscess, furuncle, osteomyelitis and pyomyositis patients with staphylococcal in the commune of Zogbodomey. The 124 patients were profiled based on sociodemographic, clinical, microbiological, hematological and immunological parameters. Then CRP, SV, NB and CD4 were evaluated in for 4 weeks. The patients were predominantly female (sex ratio = 0.8) and the age group [1; 10 years] was the most represented (68.55%). Before the medical consultation, 54.03% of the patients first used traditional medicine to treat themselves and 10.28% used probabilistic antibiotic therapy. All the isolated *S. aureus* strains were isolated in pure culture in the cases of pyomyositis and 29.61% of *S. aureus* strains are resistant to the tested antibiotics. The isolated *S. aureus* strains are 100% sensitive to vancomycin and ciprofloxacin. LPV was produced by 73.98% of *S. aureus* strains and 89.15% are sensitive to methicillin. The follow-up showed that patients with LPV+ presented at the beginning of the treatment, a hyperleukocytosis (91.18%) and a decrease of CD4 compared to those with LPV. Furthermore, a progressive improvement of the immunological parameters was noted, which became routine in almost all patients in the 4th week of follow-up. LPV-producing *S. aureus* is essential in staphylococcal infections in the study area. The presence of methicillin-sensitive strains suggests the loss of resistance gene by horizontal transfer.

**Key words:** Benin, community, LPV, *S. aureus*, staphylococcal skin infections.

**INTRODUCTION**

*Staphylococcus aureus* harmlessly colonizes the skin and mucous membranes of approximately 30% of healthy
adults (Gorwitz et al., 2008). It is the most common cause of mild skin and soft tissue infections, such as abscesses and wound infections. These infections cause many primary care visits, but rarely result in hospitalization or surgical treatment. The incidence of community-acquired invasive staphylococcal infections, such as pneumonia or osteomyelitis, is low (Hayward et al., 2008). But, S. aureus is a common cause of healthcare-associated diseases, with methicillin-resistant S. aureus (MRSA) strains reported in hospitals and healthcare facilities in most industrialized countries (Shallcross et al., 2013). These strains often produce a specific virulence factor, Panton-Valentine leucocidin (PVL) (Otto, 2014). This toxin is also responsible for a much more severe emerging pathology, staphylococcal community-acquired necrotizing pneumonia (Gillett et al., 2001).

Panton-Valentine leucocidin-producing S. aureus (PVL-SA) is a recognized cause of recurrent multifocal skin and soft tissue infections (MSI), necrotizing pneumonia (NP), and severe musculoskeletal infections, especially in children (Health Protection Agency, 2008; Saeed et al., 2018). It is characterized by fever, hemoptysis, multinodular alveolar infiltrates and leukopenia, the latter possibly related to the pro-apoptotic effect of LPV on neutrophils (Saeed et al., 2018). Furthermore, relapse after adequate treatment is common in the absence of decolonization (Saeed et al., 2018; Nurjadi et al., 2015).

The biological criteria for skin infection diagnosis are most often elevated C-reactive protein, sedimentation rate, and blood count, significantly decreasing leukocytes. Suspicion may arise from certain characteristic features, but a confirmed diagnosis requires special non-routine tests. Given its increasing prevalence (Fogo et al., 2011; Vindel et al., 2014; Waldenburger et al., 2014), understanding the specific features and risk factors of PVL-SA is necessary for better clinical practice. In this work, we characterize all recorded PVL-SA infections diagnosed in the “Réservoir de Siloé” health center in Hlagba-ouassa, commune of Zogbodomey. This center received patients with staphylococcal skin diseases (wounds, abscesses, furuncles, osteomyelitis, and pyomyositis). In view of this situation, and for good sound management of these diseases, we decided to highlight the role of Panton-Valentine leucocidin in staphylococcal skin diseases through the profile and immunological follow-up of patients in peri-urban areas in Benin.

**MATERIALS AND METHODS**

**Study setting**

The "Réservoir de Siloé" health center in Hlagba-ouassa, the village of investigation, served as a setting for the reception, sampling, and treatment of patients, except for cases of complications. The microbiology and pediatrics laboratories of the Centre Hospitalier Départemental Zou Collines (CHD Z /C.) were used to process the samples. In addition, the biology and molecular typing in microbiology laboratory served as a setting for the research of Panton and Valentine leucocidin on S. aureus strains.

**Inclusion criteria**

This study includes samples from patients with abscesses, boils, myositis and/or supportive wounds. Finally, samples from patients that gave their consents were considered for analysis.

**Type and period of the study**

This study focused on a cohort of 124 patients with staphylococcal diseases received at the health center "Réservoir de Siloé" of Hlagba-ouassa, commune of Zogbodomey from November 2014 to December 2017. Data were collected retrospectively in 71 patients and prospectively and longitudinally in 53 patients. The profile of the 124 patients was established based on sociodemographic, clinical, microbiological, hematological, and immunological parameters. Then the immunological follow-up of the cohort of 53 patients (34 LPV+ and 19 LPV-) was performed weekly for four weeks on the following parameters: CRP, VS, white blood cell count, and T4 lymphocyte. For the retrospective study, all the data were provided by the registers of surgical reports and laboratory registers. For the prospective study, the data were collected from the patients' and accompanying persons' histories; the biological examinations were systematically requested for to diagnose the disease and/or treatment.

**Clinical diagnosis**

Based on clinical diagnosis, 124 samples (from abscesses, boils, myositis and supportive wounds) are taken using sterile swabs directly inoculated in nutrient broth and in an aseptic environment. All samples are transferred to the laboratory, incubated at 37°C and processed.

**Microbiological diagnosis**

After fresh examination and Gram staining, each sample was culture on Mac Conkey and Chapman agar medium using a platinum loop. After 18 to 24 h, the bacteria have a characteristic morphology and suspected colonies are plated on nutrient agar and subjected to Gram staining and identification tests. Gram (+) positive Cocci colonies are subjected to catalase and free coagulase and DNDase tests. Gram (-) bacilli, after reading the characteristics on the selective agar medium, are subjected to the classical identification test of Enterobacteria.

**Susceptibility of strains to antibiotics**

Each strain was tested for its sensitivity to 13 antibiotics (Bio Rad®): penicillin (Benzyl penicillin) (10 IU), oxacillin (5 µg), erythromycin (15 µg), gentamicin (10 µg), chloramphenicol (30 µg), tetracycline (30 µg), ciprofloxacin (10 µg), and vancomycin (30 µg).

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The agar disk diffusion method was used to perform the
antibiogram. A bacterial suspension prepared from a 24-hour
culture of *S. aureus* on agar medium and standardized to 0.5 Mc
Farland was swabbed onto the surface of the Mueller-Hinton
medium. After applying antibiotic discs, the plates were incubated
at 37°C for 24 h. The isolates were categorized as sensitive (S) or
resistant (R) to the different antibiotics according to
the recommendations of the Antibiogram Committee of the French
Society of Microbiology (CASFM/EUCAST, 2019).

Data analysis

Microsoft Excel spreadsheet version 2016 was used for data entry
and coding. GraphPad Prism (version 8.0) was used to create the
graphs and analysis of variance (ANOVA). Finally, a structuring
the averages allowed us to compare and interpret the different results
due to a t-test on data (R software). The differences are
considered significant if the p-value < 0.05 and very significant if the
p-value < 0.001.

RESULTS

Characteristics of the sample

During the study, 124 patients were followed up. The
most infected age group was 1-10 years (54.03%)
followed by 11-20 years (27.42%). The male/female sex
ratio is equal to 0.80; with a female predominance
The distribution of patients according to age and sex are
shown in the Table 1.

Table 1. Distribution of patients according to sex and age group.

<table>
<thead>
<tr>
<th>Age</th>
<th>1-10 years</th>
<th>11-20 years</th>
<th>21-30 years</th>
<th>≥31 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>36</td>
<td>19</td>
<td>11</td>
<td>3</td>
<td>69 (55.65%)</td>
</tr>
<tr>
<td>Men</td>
<td>31</td>
<td>15</td>
<td>7</td>
<td>2</td>
<td>55 (44.35%)</td>
</tr>
<tr>
<td>Total</td>
<td>67 (54.03%)</td>
<td>34 (27.42%)</td>
<td>18 (14.52)</td>
<td>5 (4.03)</td>
<td>124 (100)</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Inflammatory anemia

During chronic inflammatory syndromes, hyposideremia and
anemia rarely below 8 g/L appear. Ferritinemia increases and the
total siderophilin binding capacity tends to decrease. On the
contrary, in maternal deficiency, the body's iron stocks are depleted.
To try to compensate for this deficit, the total binding capacity of
siderophilin increases. In a mixed inflammatory and deficiency
situation, ferritin levels may be abnormally normal or even
increased. If an increase in the total siderophilin binding capacity is
found during an inflammatory syndrome, there is a maternal
deficiency which the ferritin level will confirm.

Profile of patients with staphylococcal diseases

Table 3 shows the distribution of patients by age group
and skin condition. The table shows that the age group 1
to 10 years is the most affected, regardless of the type of
disease. The most common diseases were pyomyositis
(42.74%), osteomyelitis (24.19%) and abscesses
(20.97%).

Previous treatments

Figure 1 shows the distribution of patients according to
Table 2. Distribution of patients by occupation.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Craft man</th>
<th>Farmer</th>
<th>Housekeeper</th>
<th>Teacher</th>
<th>Nurse</th>
<th>Student</th>
<th>Without profession</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>5</td>
<td>2</td>
<td>24</td>
<td>3</td>
<td>1</td>
<td>19</td>
<td>70</td>
<td>124</td>
</tr>
<tr>
<td>Percentage</td>
<td>5.56</td>
<td>2.22</td>
<td>19.35</td>
<td>2.42</td>
<td>1.11</td>
<td>15.32</td>
<td>56.45</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Table 3. Distribution of the 124 patients according to their age group and disease.

<table>
<thead>
<tr>
<th>Illness</th>
<th>1-10 years</th>
<th>11-20 years</th>
<th>21-30 years</th>
<th>≥31 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyomyositis</td>
<td>28</td>
<td>12</td>
<td>10</td>
<td>3</td>
<td>53 (42.74%)</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>25</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>30 (24.19%)</td>
</tr>
<tr>
<td>Abscess</td>
<td>21</td>
<td>05</td>
<td>0</td>
<td>0</td>
<td>26 (20.97%)</td>
</tr>
<tr>
<td>Furuncle</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>10 (8.06%)</td>
</tr>
<tr>
<td>Wounds</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>05 (4.03%)</td>
</tr>
<tr>
<td>Total</td>
<td>85 (68.55%)</td>
<td>22 (17.74%)</td>
<td>13 (10.48%)</td>
<td>04 (3.23%)</td>
<td>124 (100%)</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Figure 1. Distribution of patients according to the treatment followed at home.

Source: Authors 2023.

the treatment followed at home. The analysis of this figure indicates that 54.03% of the patients use traditional medicine to treat themselves and only 10.28% use probabilistic antibiotic therapy.

Hematology profile

Hematological examinations were performed on blood samples taken from 96 of the 124 patients in our study.

Bacterial species isolated according to the type of infection

The results of the hematological investigations are shown in Table 4. It appears from this table that the patients are often anemic (85.42%). Hyperleukocytosis was also noted in 86.46% of patients.

Figure 2 shows that *S. aureus* was isolated in 83.11% of
Table 4. Distribution of haematological test results according to the age group of the patients.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Anemia (%)</th>
<th>Hyperleukocytosis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1 - 10</td>
<td>38.54</td>
<td>4.17</td>
</tr>
<tr>
<td>11 - 20</td>
<td>28.13</td>
<td>3.13</td>
</tr>
<tr>
<td>21 - 30</td>
<td>13.54</td>
<td>4.17</td>
</tr>
<tr>
<td>≥ 30</td>
<td>5.21</td>
<td>3.13</td>
</tr>
<tr>
<td>Total (%)</td>
<td>85.42</td>
<td>14.58</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Infectious diseases

Figure 2. Distribution of bacterial strains according to infections.

Source: Authors 2023.

the cases studied. Most cases of S. aureus were isolated in pure culture in 100% of the cases of pyomyositis. There was no significant difference between the bacterial strains according to the infections (p >0.9999).

Sensitivity of S. aureus strains to antibiotics

Figure 3 shows that 29.61% of S. aureus strains are resistant to the antibiotics tested, including 100% to penicillin. In addition, 70.39% of S. aureus strains are sensitive to the antibiotics tested, including 100% to vancomycin, gentamycin and ciprofloxacin.

Panton-Valentine leucocidin (LPV) result

Ninety-one strains of S. aureus out of 123 isolated produced Panton-Valentine leucocidin (PVL), representing 73.98% of the strains tested (Table 5).

Figure 4 shows the susceptibility of LPV-producing S. aureus strains to methicillin. This figure, that all LPV-producing S. aureus strains are sensitive to methicillin at the same time, 40.63% of non-LPV-producing S. aureus
Figure 3. Susceptibility of *S. aureus* strains to antibiotics. Source: Authors 2023.

Table 5. Distribution of *S. aureus* strains according to LPV production and conditions.

<table>
<thead>
<tr>
<th>Disease</th>
<th>LPV (+)</th>
<th>LPV (-)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyomyositis</td>
<td>25</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>40</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Abscess</td>
<td>15</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Furuncle</td>
<td>09</td>
<td>0</td>
<td>09</td>
</tr>
<tr>
<td>Wounds</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>32</td>
<td>123</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Figure 4. Susceptibility of LPV-producing *S. aureus* strains to meticillin. MSSA: Methicillin-sensitive *S. aureus*; MRSA: Methicillin-resistant *S. aureus*. Source: Authors 2023.
strains are resistant to methicillin. There was no significant difference between methicillin-susceptible and methicillin-resistant S. aureus strains (p >0.9999) according to the production of LPV.

Immunological profile of patients

Retroviral serology and C-reactive protein (CRP) which is an inflammatory response protein were performed on the patient samples obtained and are summarized in Table 6. According to the table, the majority of the patients are seronegative with a CRP level higher than 6 mg/l.

Evolution of CRP during the follow-up of patients with SA-LPV

Figure 5 shows SV values in the patients at each week of treatment. It was noted that at the beginning of the treatment, CRP was positive in 100% of the LPV+ patients and the values vary globally between 12 and 48 mg/ml, with a median of 48 mg/ml (Figure 5A). After that, a progressive decrease in SV was observed between the first and fourth week, when most patients had a negative CRP value of 6 mg/ml. Finally, in the 4th week, the CRP was negative in 31/34 patients, that is, 91.18% of the negativity rate.

In LPV- patients, CRP positivity was also 100% at the beginning of the follow-up. However, the values were lower from the second week onwards than in LPV+ patients. In the 4th week, almost all patients became CRP-negative.

The curve showing the variation of CRP during treatment shows a decreasing trend in both LPV+ and LPV- patients. At the beginning of the follow-up, the average CRP of LPV+ patients (45.18 mg/L) were higher than that of LPV- patients (40.59 mg/L). But from the second week onwards, the averages are lower in LPV-patients (Figure 6). Moreover, the t-test on paired data shows that from the 3rd week of follow-up, statistically significant differences are observed with the CRP means of the 1st week.

Evolution of SV during follow-up

Figure 7 shows the distribution of SV values at each week of treatment. At week 1, the SV ranged from 30 to 120 mm with a median of 55 mm. At the 2nd week the
median is maintained at 55 mm, but a more significant variability of results is noted. At the 3rd week of follow-up, the median is 30 mm. It decreases to 20 mm at the 4th week.

Similarly, the analysis of Figure 8 shows that the mean of the SV progressively decreases from the 1st to the 4th week of follow-up with respective values of 61.74 and 34.05 mm for LPV+ patients against 61.05 and 16.11 mm for LPV. In addition, a comparison of the mean by t-test reveals statistically significant differences between the SVs at the beginning of treatment and those at the 3rd and 4th week.

**Evolution of T4 lymphocytes during the follow-up of SA-LPV patients**

Figure 9 shows the distribution of T4 lymphocyte values between the 1st and 4th week of follow-up. In LPV-patients, the C values are all above 400. These values are atypical, so this parameter does not need to be monitored in LPV- patients. On the other hand, in LPV+ subjects, it was noted that in the first week of follow-up, the T4 lymphocyte values are between 63 and 380. The median is equal to 190. But in the 4th week the CD4 values increased significantly with a median distribution

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**Figure 6.** Variation in mean CRP during patient follow-up. 
Source: Authors 2023.

**Figure 7.** Distribution of CRP values during the follow-up of patients. 
Source: Authors 2023.

**A:** Evolution of SV during follow-up in LPV+ patients.  
**B:** Evolution of SV during follow-up in LPV- patients.
The average 187.15 at the beginning of the treatment increased to 313.23 at the 4th week of follow-up, that is, an increase of 67.37% (Figure 10). This difference is statistically significant (p=0.000).

**Evolution of the white blood cell count during the follow-up of LPV+ patients**

The white blood cell count was higher in the first week (Figure 11). The values vary from 2500 to 14000 mm$^3$, and hyperleukocytosis is present in 91.18% of the subjects (Table 6). In the 4th week, leukocyte values were very little scattered (Table 7). The values were normal in 67.65% of cases, and there was no more hyperleukocytosis (Table 7).

In addition, there was a statistically significant decrease (p=0.000) in the mean leukocyte count from baseline to week 4 in LPV+ patients with 10041 and 4226 NB/mm$^3$, respectively (Figure 12).

**DISCUSSION**

The involvement of PVL in *S. aureus* virulence has been
a controversial topic for many scientists in search of factors responsible for the high pathogenicity of community-associated *S. aureus* strains. In this study, the role of Panton-Valentine leucocidin-producing *S. aureus* in Staphylococcal skin diseases was examined by studying a cohort of patients with community-acquired *S. aureus* in a context of pyomyositis and osteomyelitis in a peri-urban area of Benin to contribute to its eradication.

The majority of the cases followed were children (54.03%). These results are superior to those obtained by Vieu (2014), who showed that 42% of the patients in their cohort were children under 15 years of age. The size of the cohort could explain this difference. Their cohort size was 37 patients, whereas ours was 124 patients. In addition, the epidemiological association between children and PVL+ *S. aureus* disease is well described in the

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**Figure 10.** Change in mean CD4 T cell count between 1st and 4th week of follow-up in LPV+ patients.

Source: Authors 2023.

**Figure 11.** Distribution of T4 lymphocyte values between the 1st and 4th week of follow-up.

Source: Authors 2023.
Table 7. Leukocyte abnormalities observed between the 1st and 4th week of follow-up.

<table>
<thead>
<tr>
<th>Follow-up period</th>
<th>Parameter followed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st week</td>
<td>Leukopenia</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>Hyperleukocytosis</td>
<td>91.18</td>
</tr>
<tr>
<td></td>
<td>Standard value</td>
<td>2.94</td>
</tr>
<tr>
<td>4th week</td>
<td>Leukopenia</td>
<td>32.35</td>
</tr>
<tr>
<td></td>
<td>Hyperleukocytosis</td>
<td>67.65</td>
</tr>
<tr>
<td></td>
<td>Standard value</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Authors 2023.

Figure 12. Variation of the average leukocytes between the 1st and the 4th week of follow-up. Source: Authors 2023.

literature (Carré, 2010). However, our cases involve community-acquired skin conditions. Children have been described as a group at risk of developing staphylococcal disease regardless of PVL status (Gillet et al., 2002). The communal life can explain this observation in schools, which favors contact and transmission, particularly through the carriage of S. aureus.

According to Vieu (2014), management is marked by the need for antibiotic therapy or surgery as soon as a pus focus is present. Clinical improvement after drainage of the abscess is immediate, but effective antibiotic treatment is still necessary to avoid a relapse. In our cohort, 10% of patients resorted to traditional medicine and probabilistic antibiotic therapy for treatment. This observation can be explained by their culture and may have led to the death of 8 patients.

Regarding the microbiological quality of the conditions, more than half (61%) of S. aureus was isolated in pure culture. Staphylococcus is the germ most frequently involved in pilosebaceous follicle infections. Many factors favor the occurrence of this type of infection, whether local (friction, tight clothing, maceration, hyper sudation, scratching, shaving, depilation, irritating topicals, oil applications, dermo corticoids, isotretinoin) or general (obesity, diabetes, congenital or acquired immune deficiency, dialysis renal failure) (Larquey and Mahé, 2018). These strains of community-acquired S. aureus have the potential to produce a toxin associated with severe skin infections, the Panton-Valentine (PVL) leucocidin toxin. SA-PVL strains represent approximately
93% of the *S. aureus* strains in our cohort. This value is similar to that of Le Monnier (2002) but slightly higher than that of Vandenesch et al. (2003) which is 72.22%. This precariousness can explain this difference in results and lack of hygiene observed in the study area. SA-PVL strains are virulent and spread very rapidly. Human-to-human transmission occurs through direct or indirect (hand-to-mouth) contact with a purulent lesion, a carrier or contaminated surface, linen or objects (Castellazzi et al., 2021). Staphylococci-producing Panton-Valentine leucocidin is all sensitive to methicillin. This result is unexpected given the community origin of these isolates, where 10% of our patients use probabilistic antibiotic therapy. However, it cannot be extrapolated to all community-acquired SAMS-LPV+ because of treatment selection bias. From studies by Khatib et al. (2013), SAMS-LPV+ is still the leading cause of severe Panton and Valentine leucocidin-associated infections in many countries. It is thus the most plausible reservoir of community-acquired methicillin-resistant *S. aureus* (CA-MRSA). In the United States, most reported cases are caused by community-acquired methicillin-resistant strains (CA-MRSA). Although an increase in cases of PVL + CA-MRSA has been reported, the expression of PVL remains predominantly associated with MSSA in Europe (Moran et al., 2006; Witte et al., 2007; Rasigade et al., 2010; Shore et al., 2014). Furthermore, according to national epidemiology data from France in 2008, 43% of SA-LPV+ were susceptible to methicillin (Nizou, 2014). Like other staphylococci, they almost systematically express a penicillinase responsible for penicillin resistance. Antibiotic treatment of these infections does not pose major problems, as these germs are mainly sensitive to vancomycin and ciprofloxacin.

Furthermore, the hematological examinations showed that most of our patients are anemic followed by a neutrophilic hyperleukocytosis as soon as they are admitted for treatment, that is, about 65% of our SA-LPV+ patients. This result is in agreement with the assertion of Le Monnier (2002) that it is a cytotoxin destroying leukocytes and inducing tissue necrosis. It is a synergohymenotropic toxin, that is, a toxin that destroys leukocytes by causing major ionic disorders after the release of cytokines (class F and S proteins) that act synergistically and then activate proteases at the intracellular level that in turn induce apoptosis and cell death.

Most patients are seronegative with a CRP level higher than 6 mg/l on admission. Despite this seronegative result, a depletion of T4 lymphocytes in most patients was observed. When the infectious agent is eliminated, the effector cells will die (T4 lymphocytes) and only the antigen-specific memory cells will persist. The frequency of precursor T cells in the immune repertoire before antigen exposure determines the magnitude of the immune response in humans (Su and Davis, 2013; Nelson et al., 2015; Su et al., 2013). The smaller the number of self-peptides homologous to a given antigen, the greater the frequency of CD4 T cells naïve to that same antigen in the immune repertoire. Follow-up of patients for four weeks showed a clear improvement of immunological parameters in most patients. Although the literature does not say much about this case, this indicates the impact of LPV on the immune system of LPV+ patients.

CRP is a biomarker of the inflammatory response, which can predict the severity and prognosis of an infection (Zhang et al., 2020; Liu et al., 2020b). It activates the classical complement pathway to stimulate bacterial phagocytosis during bacterial infection. When bacterial inflammatory factors are eliminated, CRP levels decrease rapidly (Zhang et al., 2022). In this study, CRP was positive in 100% of LPV+ patients, and values ranged globally from 12 to 48 mg/ml with a median of 48 mg/ml (Figure 5A). The higher the CRP level, the more severe the infection or inflammation. Those patients with a CRP level >41.8 mg/ml are likely to develop severe disease. This was the case in a retrospective study from China that found that patients with CRP >41.8 mg/l in COVID-19 were more likely to develop the severe disease (Liu et al., 2020a).

**Conclusion**

The objective of this study was to highlight the role of Panton-Valentine leucocidin (PVL) in staphylococcal skin diseases through the profile and immunological follow-up of patients in peri-urban areas in Benin. The data analysis shows that in the study area (Hlagba-Ouassa), staphylococcal diseases are mainly characterized by myositis and abscesses. The patients, mostly children, are 85.42% anemic with hyperleukocytosis. More than half of them resort to traditional treatments before a medical consultation. *S. aureus* is a bacterial species found in almost all patients (123/124). These *S. aureus* strains are 70.39% sensitive to the antibiotics tested, including vancomycin and ciprofloxacin. LPV-producing *S. aureus* (SA-LPV+) is the leading cause of staphylococcal infections (73.98%). SA-LPV+ strains are all sensitive to methicillin. The presence of SA-LPV+ leads to immunological disorders characterized by hyperleukocytosis, a decrease T4 lymphocytes, CRP positivity, and a prolongation of the SV. All these parameters progressively decrease with treatment and generally return to normal after 4 weeks of follow-up. To date, the presence of LPV toxin is an aggravating factor in the staphylococcal disease. The combination of methicillin sensitivity and a virulence factor (LPV) represents a potential risk of severe complications in cutaneous localization of *S. aureus*. It is therefore essential, to set up specific studies to better characterize them and identify adequate control and prevention measures. It should also be noted that good hygiene is
necessary to avoid staphylococcal diseases.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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