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Original article

Impact of the Covid-19 pandemic context on the microbiological epidemiology and management of flexor sheath phlegmons

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ABSTRACT

Introduction: The COVID-19 pandemic in France has recently modified the patients' lifestyles, as well as methods of medical and surgical management. This could explain subsequent changes to the microbiological spectrum, the severity, as well as the scalability of phlegmons of the flexor tendon sheath. The objective of this study was to construct an epidemiological and bacteriological inventory of these hand infections, and to compare the clinical and microbiological data, before and after the COVID-19 pandemic.
Hypothesis: The hypothesis of this work was that the phlegmons of the flexor tendon sheath presented specific microbiological characteristics in the tropical environment of our University Hospital Center, and that these characteristics could have changed with the recent introduction of hydro-alcoholic solution (HAS) associated to the COVID-19 pandemic.
Material and methods: The preoperative epidemiological data of our patients were collected between January 2016 and December 2020. The stage of severity, according to the classification of Michon, the use of hydro-alcoholic solution, as well as the early clinical evolution were collected. The cohort was then divided into two groups in order to compare the microbiological profiles, the management and the clinical evolution of patients in the pre-COVID period with those in the post-COVID period.
Results: A total of 199 patients were included, 154 patients in the pre-COVID period and 26 in the post-COVID period. We found a majority of MSSA (58.3%, N = 105) and negative samples comprised 18.9% (N = 34). No statistically significant difference was found between the two groups regarding the bacteriological results. The clinical course was judged to be favorable in 93.5% of cases in the pre-COVID group compared to 80.8% in the post-COVID group ($p = 0.046$). The use of HAS ($p < 0.0001$), as well as the initial stage of severity according to Michon, were significantly higher in group 2 ($p = 0.04$).
Discussion: The COVID-19 pandemic has not shown any change in the microbiological spectrum, despite the now daily use of HAS in everyday life. The postoperative clinical evolution was significantly less favorable after the onset of COVID and could be explained by an increase in cases with a more advanced initial stage of severity.
Level of evidence: IV, Observational epidemiological study.

1. Introduction

A phlegmon of the flexor tendon sheath of the hand corresponds to an acute infection, in a closed space, requiring urgent management to limit potential functional impairments. Kanavel classified this entity as a serious hand infection [1]. Its incidence represents between 2.5% and 9.4% of all hand infections [2]. Infection can be caused by direct or indirect inoculation and haematogenous spread. The direct communication between the different sheaths often makes its dissemination rapid, and can extend to the wrist. In addition, the closed nature of the infection makes it more resistant to medical treatment. Since the beginning of the COVID-19 pandemic period, a significant increase in hand wounds and infections, at greater levels of severity than in the pre-COVID period, has been reported [3–5]. Alternately, despite the introduction of daily use of hydro-alcoholic solution, no study in the field of orthopaedic traumatology has focused on its effect on the bacteriological profiles of patients with hand infections,

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and even less investigated, it's possible effect on the modification of commensal flora in the short and medium term.

The objective of this study was to characterize the bacteriological spectrum of these hand infections and to compare the clinical and microbiological data before and after the COVID-19 pandemic. The hypothesis of this study was that phlegmons of the flexor tendon sheath, in tropical environments, presented specific microbiological characteristics which could also have changed with the recent introduction of hydro-alcoholic solution associated to the COVID-19 pandemic.

2. Materials and methods

2.1. Study population

This descriptive epidemiological study was conducted on patients hospitalized in the hand emergency department of our University Hospital Center between January 1, 2016 and December 31, 2020. All medical records were found via the medical information department (MID) by entering the following CCAM codes: MJJA001, MJJA002, MJJA004. The inclusion criteria were: any patient over the age of 15 with urgent hand treatment for a phlegmon of the flexor tendon sheath, presenting with at least one Kanavel sign[6] in addition to pathognomonic pain at the "cul de sac", and having benefited from surgical management. The exclusion criteria were: any patient under 15 years of age, whose clinical follow-up was less than 48 hours, or who had not had deep bacteriological sampling of fluid from the sheath in the operating room. The cohort was then divided into two groups in order to compare the microbiological profiles, management and clinical course of patients in the pre-COVID-19 period (group 1) with those in the post-COVID-19 period (group 2). The start date of the post-COVID-19 period was 16/03/20, corresponding to the first day of confinement of the first wave.

2.2. Surgical protocol

The surgical protocol was of the hand emergency department of our establishment. The surgical procedure, depending on the Michon stage [7], was systematically performed by a senior surgeon; stage 1 corresponded to an increase in the quantity of synovial fluid, stage 2 to synovial fluid in increased volume, purulence, or macroscopically suspicious without lesions of the sheath, and stage 3 to septic necrosis of the sheath and/or pulleys. Thus, all stage 1 phlegmons had an excision at the entry point, a counter incision next to the A1 pulley with anterograde wash-out. For stage 2, a wide excision of the entry point accompanied by an incision along the path of the Brunner-type sheath and a synovectomy was performed. Finally, stage 3 could be subject to excision of the tendon and pulleys with the possibility of amputation. Cutaneous closure was systematically carried out with non-absorbable separate skin stitches, with eversion of their edges. All patients received empirical post-operative antibiotic therapy with amoxicillin-clavulanic acid, or macrolides if an allergy was present, which was secondarily targeted to the antibiogram with the opinion of the bone and joint infections multidisciplinary consultation meeting in our establishment. The duration of antibiotic therapy was 5 to 7 days in the absence of complications.

2.3. Evaluation criteria

All the preoperative epidemiological data were collected, as well as the stage of the phlegmon according to Michon [7], the use of hydro-alcoholic solution as well as the scalability during the check-up consultation on D2.

The following epidemiological data and comorbidities were collected: age, sex, diabetes, hypertension (HTN), alcohol use, substance use, tobacco use, and any other notable history.

The topography, laterality, classification of Michon and the mode of contamination (penetrating trauma, bite, animal or plant bite, contiguity, postoperative, undetermined) were also collected.

Regarding the microbiology, deep samples from the operating room were collected for bacterial strain typing, the antibiogram was identified to assess potential resistance to the empirical antibiotic therapy administered, as well as potentially diminished bacterial identification due to antibiotic intake prior to management.

The use of hydro-alcoholic solution (HAS) was quantified by the average number of daily applications after questioning the patient.

The information relating to the surgical management made it possible to inform the type of surgery according to Sokolow [8], adapted to the classification of Michon (stages 1,2 and 3), with possible amputation, joint wash-out and/or curettage of the osteitis site if necessary.

The clinical evolution was evaluated 48 hours postoperatively. In accordance with the criteria validated by the Centers for Disease Control and Prevention (CDC), Atlanta, and the hygiene council of the French National Authority for Health [9,10], a favorable evolution at 48 hours (D2) was defined by the following criteria: absence of revision surgery, apyrexia, reduction of inflammatory signs (redness, heat, swelling, pain), scar oozing and/or scar disunity.

2.4. Statistical analysis

The data was collated into an Excel spreadsheet. Statistical analysis was performed using JMP® 11.0.0 software (SAS Institute Inc.). The normal distribution of the quantitative variables was checked using the Shapiro-Wilk test. The comparison of quantitative variables was carried out using a Student's t test, and the comparison of qualitative variables using a Chi^2 or Fisher test. The difference was considered significant when $p < 0.05$.

3. Results

3.1. Descriptive epidemiology

Between 01/01/2016 and 31/12/2020, out of a total of 199 eligible patients, 180 patients were included (Figure 1). For the 19 patients excluded, reasons included: absence of bacteriological samples (N = 6), absence of follow-up exceeding 48 hours and/or loss to follow-up (N = 13).

The average age was 48.52 years (Min 16 - Max 83) with a large majority of male patients (71.7%). The most common comorbidities encountered were: diabetes (15.5%) and hypertension (11.7%). The most common mechanism of infection encountered was penetrating trauma (27.8%). The stage of severity according to Michon reported 42.2% of patients presenting with stage 1 (N = 76), 51.7% with stage 2 (N = 93) and 6.1% with stage 3 (N = 11).

There was a correlation between Michon stages 2 and 3 and the presence of hypertension, with respective values $p = 0.009$ (OR= 4.06; CI: 1.47-11.23) and $p = 0.027$ (OR= 5.109 CI:1.436-18.176).

The presence of diabetes was also more common for stage 3 according to Michon ($p = 0.015$, OR= 5.29; CI: 1.578-17.850).

All the epidemiological data are reported in Table 1.

3.2. Bacteriological profile

A total of 78.9% of infections were monobacterial (N = 142), 1.7% of them were polybacterial (N = 3), while 19.4% could not be identified after culture (N = 35).

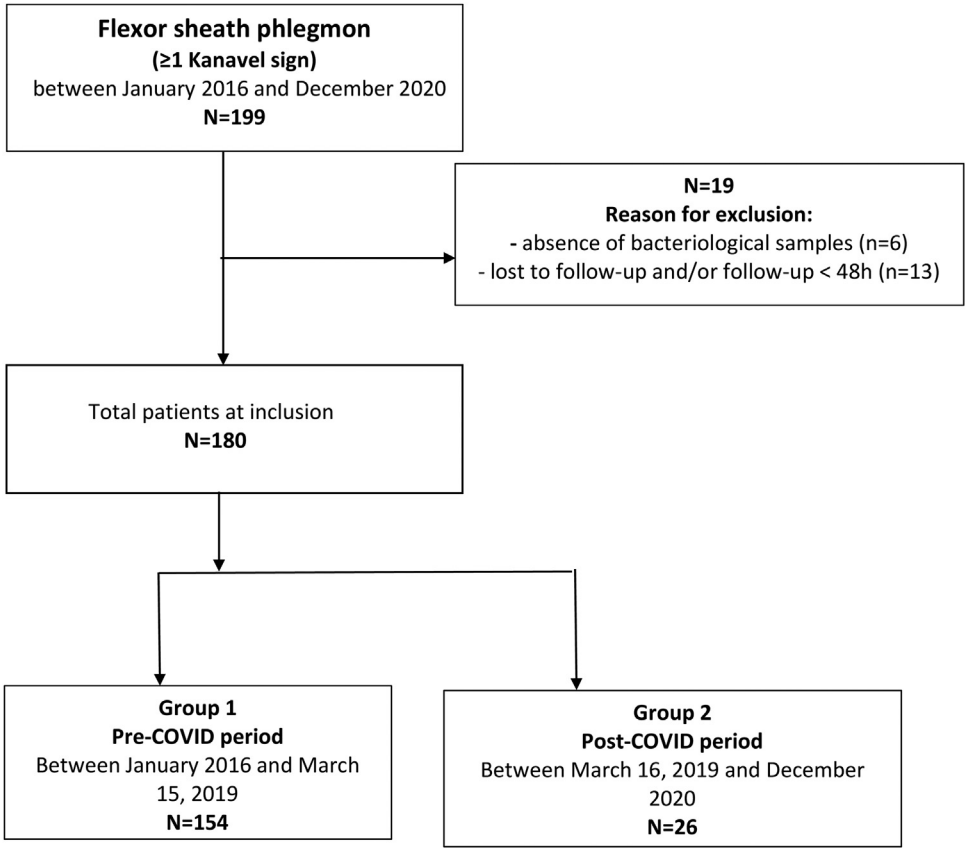

Figure 1. Patient flow chart. Total patients at inclusion N = 180.

Table 1
Epidemiological data and stage of severity of the study group (N= 180).

Epidemiological data	N = 180
Sex	
Male	129 (71.7%)
Female	51 (28.3%)
Age	48.52 ± 18.3
Comorbidities	
Diabetes	28 (15.5%)
HTN	21 (11.7%)
Smoking	8 (4.4%)
Alcohol	3 (1.7%)
HIV	3 (1.7%)
Type of injury	
Penetrating trauma	50 (27.8%)
Bite	10 (5.6%)
Animal sting	25 (13.9%)
Plant sting	11 (6.1%)
Continuity	29 (16.1%)
NC	54 (30%)
Post-op	1 (0.5%)
Laterality	
Right	91 (50.5%)
Left	89 (49.5%)
Finger of the hand	
First	31 (17.2%)
Second	47 (26.1%)
Third	82 (45.5%)
Fourth	28 (15.5%)
Fifth	23 (12.7%)
Michon stage	
1	76 (42.2%)
2	93 (51.7%)
3	11 (6.1%)

Table 2
Bacteriological data of the entire study group (N = 180).

Bacteriological identification	N (%)
Staphylococcus	113 (62.8%)
MSSA	106 (58.9%)
MRSA	3
Coagulase negative	4
Streptococcus	14 (7.8%)
A	5
B	6
Non-a Non-b	3
GNB	21 (11.7%)
E. coli	3
Aeromonas hydrophila	1
Klesbiella	3
Pasteurella	1
Citrobacter	3
Pseudomonas aeruginosa	1
Pseudomonas fluorescens	1
Panteoa agglomerans	1
Proteus	3
Morganella morganii	1
Acinetobacter baumani	1
Chryseobacterium indologenes	1
	1
Negative sample	35 (19.4%)
MRB	8 (4.4%)
Polymicrobial	3 (1.7%)

Staphylococci comprised the majority of the sample (N = 113, 62.8%) of which 105 (58.3%) were methicillin-sensitive Staphylococcus aureus (MSSA). Streptococci were found in 7.8% (N = 14) and gram-negative bacillus (GNB) in 11.7% (N = 21) of the results (Table 2).

Table 3
Comparison of epidemiological data between group 1 (pre-COVID) and group 2 (post-COVID).

	Pre-COVID	Post-COVID	p
N	154	26	
Age (years ± DS)	49.1 ± 18.5	44.0 ± 17.0	0.18
Sex (F/M)	44/110	7/19	0.86
Diabetes	26 (16.88%)	2 (7.69%)	0.38
HTN	16 (10.4%)	5 (19.2%)	0.22
Penetrating trauma	48 (31.2%)	2 (7.7%)	0.016
Animal bite	7 (4.6%)	3 (11.5%)	0.16
Animal sting	19 (12.3%)	6 (23.1%)	0.17
Plant sting	7 (4.55%)	4 (15.4%)	0.56
Sepsis by contiguity	26 (16.9%)	3 (11.54%)	0.77
Undetermined origin	46 (29.9%)	8 (30.8%)	0.77
Stage according to Michon (% stage I/II/III)	54%/39%/7%	31%/69%/0%	0.04
Favorable evolution at 48 h	144 (93.5%)	21 (80.8%)	0.046

Eight bacteria (4%) were considered as multi-resistant bacteria (MRB).

Twenty patients were given preoperative empirical antibiotic therapy by the attending physician. No correlation was found between this antibiotic intake and the negativity of the samples ($p = 0.86$).

3.3. Treatment and clinical course evolution

All patients benefited from surgical management, but 12 of them (6.7%) required surgical revision for an unfavorable evolution. There were 2 joint wash-outs for septic arthritis (1.1%) and 5 amputations (2.8%).

All patients received postoperative curative antibiotic therapy, including 164 with Augmentin 1gx3 monotherapy, for an average duration of 6.8 ± 3.5 days. Only 16 patients (8.9%) required a change of antibiotic therapy, due to bacterial resistance, following antibiogram result analysis.

The evolution at 48 hours was considered favorable for 165 (91.7%) of the patients.

3.4. Impact of the covid-19 pandemic

Group 1, corresponding to the pre-COVID 19 period (01/01/2016 to 03/16/2020), consisted of 154 patients. Group 2, corresponding to the post-COVID 19 period (03/16/2020 to 12/31/2020), consisted of 26 patients.

The two groups were homogeneous in terms of age, sex, comorbidities and lesion location (Table 3). It should be noted that a statistically significant difference was found concerning the occurrence of penetrating trauma in favor of group 1 ($p = 0.016$). The severity stage according to Michon (1, 2 and 3) was respectively 54%, 39% and 7% for group 1 and 31%, 69% and 0% for group 2. The initial severity was significantly greater in group 2 post-COVID ($p = 0.04$, Chi^2 test).

Staphylococcus was the most frequently identified bacteria, in 63% of cases for group 1 and 61.5% of cases for group 2 ($p = 0.89$). There was also no significant difference identified between the two groups concerning the other bacteria (GNB and streptococci) and the rate of negative samples ($p = 0.56$) (Table 4).

The evolution at 48 hours was considered favorable in 93.5% of cases for group 1 and in 80.8% of cases for group 2, with a statistically significant difference ($p = 0.046$). Finally, there was a significant difference between the use of HAS in the pre-COVID period and that in the post-COVID period (0.2 ± 1.3 versus 4.8 ± 1.9 with $p < 0.0001$).

4. Discussion

4.1. Epidemiological and microbiological analysis

The rate of staphylococcal infection found in our study seems slightly above those in the literature, with rates varying between 25 and 60% [11–15]. Nevertheless, the rate of infection with Gram+ cocci (70.8%) is comparable to data in the literature, ranging from 30 to 80% [16–18]. These results confirm that a majority of these soft tissue infections are linked to direct inoculation by the cutaneous flora and are not indicative of a difference in the cutaneous flora of our patients in tropical environments.

However, discordant data has been observed in the literature regarding the number of antibiotic-resistant bacteria, particularly MRSA, comprising 4.5% in this series. A meta-analysis conducted by Salgado et al. [19] found 30% of MRSA amongst all the retrospective series that underwent flexor phlegmons treatment, and 37% in an analysis of prospective series. This difference could be explained by the known regional disparity of MRSA, with lower carriage rates in the West Indies [20]. Apart from this low rate of resistant bacteria, no other bacteria can be identified as a risk factor for unfavorable evolution such as group A *beta-hemolytic streptococcus*, which was not identified [15].

Apart from cases of known allergy, amoxicillin-clavulanic acid was the choice for empirical antibiotic therapy in our series (91%) with only 16 patients (8.9%) requiring a modification. While some authors recommend the use of intravenous antibiotic therapy covering MRSA [11], our microbiological analysis, as well as our results in terms of favorable outcome (91.7%) and surgical revision rate (6.7%), justified our choice with early monitoring of the antibiogram results.

The risk factors for unfavorable evolution identified were: an advanced initial stage of severity according to Michon, diabetes and arterial hypertension. All these risk factors have already been identified in the literature [15]. However, we did not find significance among the other main risk factors, which are immunosuppression, tobacco and age [15,21,22].

4.2. Effect of the Covid-19 pandemic and the use of HAS

Staphylococcus was the most frequently identified bacteria, in 63% of cases for group 1 and 61.5% of cases for group 2 ($p = 0.89$). No significant difference was found between the two groups concerning the other bacteria (GNB and streptococci) and the rate of negative samples ($p = 0.56$). No microbiological data, since the start of the pandemic, concerning soft tissue infections of the hand are currently available. However, a multitude of environmental and behavioral factors could have indicated otherwise: mechanism of inoculation, use of HAS and delay in treatment.

Firstly, a statistically significant difference was found regarding the occurrence of penetrating trauma after onset of COVID-19 ($p = 0.016$). Pichard et al. [23] recently reported that hospital admissions for domestic accidents doubled during the first confinement with a significantly higher proportion of hospitalization for infection ($p = 0.03$). This explains the bacteriological similarity between the two groups given that most infections were linked to direct inoculation by cutaneous flora.

The severity stage according to Michon was significantly greater in the post-COVID group ($p = 0.04$). During this period, stage 2 phlegmons were found in 69%, compared to 39% of cases before COVID. The latter value was also similar to the 40% of stage 2 phlegmons identified by Mamane et al. [15]. This significant increase reflects the fact that following the first confinement, patients presented with more advanced stages of severity of their pathology during the initial consultation. Consequently, there was an increased rate of surgical management of trauma patients [23]. The

Table 4
Comparison of microbiological data before and after COVID-19.

	Pre-COVID N = 154	Post-COVID N = 26	p
Staphylococcus	97 (63%)	16 (61.5%)	0.89
MSSA	90	16	
MRSA	3	0	
Coagulase	4	0	
Others	31 (20.1%)	4 (15.4%)	
Streptococcus	13 (8.4%)	2 (7.7%)	0.70
B	5	1	
A	5	0	
Non-a Non-b	3	1	
GNB	18 (11.7%)	2 (7.7%)	1
Negative sample	26 (16.9%)	6 (23.1%)	0.56
Has use (Number of times/day)	0.2 ± 1.3	4.8 ± 1.9	<0.0001

main hypothesis for the delay in time until the initial consultation was the public's increased level of anxiety and stress, generated by the pandemic. In our case, a second hypothesis was also formulated; difficulty in accessing the emergency operating room during the first confinement period.

The evolution at 48 hours was considered favorable in 93.5% of cases for group 1 and in 80.8% of cases for group 2 with a statistically significant difference ($p = 0.046$). As per the literature, the initial stage of severity according to Michon is a major risk factor for an unfavorable outcome [7,15–17], which alone may explain our results. The COVID-19 pandemic resulted in a less favorable clinical course for many of our patients due to insufficient initial care, as well as restrictive measures frequently causing a delay in their care [24–26].

One of our main hypotheses formulated was that the use of HAS could modify the cutaneous bacterial flora and therefore of the bacteriological spectrum of these phlegmons. There was a significant difference between the use of HAS in the pre-COVID period and that in the post-COVID period ($p < 0.0001$), yet not significant for the bacteriological results. A trend towards an increase in negative samples was observed (18.18% against 26.9%) but not found to be significant. While no study reports the use of hydro-alcoholic solution in orthopedic traumatology, significant results have already been reported in the literature. For example, Blanckeart et al demonstrated the effectiveness of hydroalcoholic solutions against Clostridium difficile infections [27], while Prazuck et al demonstrated the effectiveness of HAS in reducing the incidence of acute gastroenteritis amongst children, during epidemics [28]. In our series, the introduction of HAS in the daily life of our patients did not statistically modify our bacteriological results.

4.3. Limitations of the study

The main limitation of this study was its retrospective nature. It nevertheless had the advantage of containing a large number of subjects compared to current data in the literature. In addition, most studies that focus on hand infections in the tropics focus on the diabetic hand [29]. Although the collection was exhaustive, the authors decided not to make conclusions regarding the incidence of phlegmon in Martinique since the emergency hand department was the only likely establishment to offer appropriate care, certain early stage phlegmons could have been incorrectly treated medically by general practitioners.

The choice of unfavorable evolution at 48 hours, as an endpoint, is debatable but was chosen to minimize loss of follow-up in our series. In the event of favorable evolution, the D2 systematic consultation for the first dressing signified, in the vast majority of cases, the last consultation. Clinical signs indicating unfavorable evolution were established based on criteria validated by the CDC, HAS and ISO-RAISIN [9,10]. The introduction of objective criteria, such as biological inflammatory markers, did not have a sufficiently large negative predictive value to make the link with diagnosis, according to Bishop et al. [30].

5. Conclusion

The bacteriological spectrum of sheath phlegmons in our University Hospital Centre, in a tropical environment, is comparable to microbiological data found in the literature, with a majority of methicillin-sensitive *Staphylococcus aureus* (MSSA), and secondly, GNB and other enterococci. The COVID-19 pandemic has not shown any change in the microbiological spectrum of patients with flexor sheath phlegmon although the use of HAS has been introduced into their daily lives. However, the postoperative clinical evolution was significantly less favorable after the onset of COVID. This unfavorable evolution can be explained by an increased number of cases with a more advanced initial stage of severity, reflecting the delay in medical and surgical management which may be linked to the patient's fear of seeking consultation during the pandemic and/or difficulties encountered when attempting to access the emergency operating room during this period.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Contribution

PP: Data collection;
CG: Corrections;
JD and LS: Corrections and data collection;
GO: Statistical analysis;
SP: Data analysis and corrections;
MS: Writing.

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