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Staphylococcus lugdunensis in children: A retrospective analysis

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ABSTRACT

Importance: *Staphylococcus lugdunensis* (*S. lugdunensis*) is a coagulase-negative staphylococcus (CoNS), found commonly as skin flora in humans. While most species of CoNS are clinically benign, *S. lugdunensis* can exhibit a similar virulence to that of *S. aureus*. However, there is scant data concerning *S. lugdunensis* infection in the pediatric population.

Objective: To ascertain local *S. lugdunensis* infection rates and sensitivity patterns in the pediatric population.

Methods: A retrospective analysis was undertaken of all *S. lugdunensis* isolates across a 6-year period from 2015 to 2020. Data were collected from electronic patient notes and laboratory records. Matrix-assisted laser desorption ionization and time of flight mass spectrometry were used to identify isolates.

Results: Ninety-six isolates of *S. lugdunensis* were identified from 86 patients. Of these, 34 isolates were treated as an infection. Twenty-three (67.6%) were found to have skin as the primary source of infection. While the observed number was small, central nervous system (CNS) sources of *S. lugdunensis* infection appear to be a significant source: all three isolates cultured from cerebrospinal fluid were clinically managed as infection. All three were associated with ventriculoperitoneal (VP) shunt infection. No cases of *S. lugdunensis* infective endocarditis were identified. About 18.6% of *S. lugdunensis* isolates were resistant to flucloxacillin.

Interpretation: *S. lugdunensis* is an uncommon but significant cause of infection in the pediatric population and appears to be a rising cause of CNS infection, particularly when associated with VP shunts. Flucloxacillin is recommended locally as the first choice of antibiotic.

KEYWORDS
Children, Infection, Pediatrics, *Staphylococcus lugdunensis*

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INTRODUCTION

First described in 1988, *Staphylococcus lugdunensis* (*S. lugdunensis*) is a coagulase-negative staphylococcus (CoNS), found commonly as skin flora in humans.[1,2] While most species of CoNS are clinically benign, *S. lugdunensis* can exhibit a virulence similar to that of *S. aureus*,[3,4] making *S. lugdunensis* a clinically significant cause of infection.[5,6] *S. lugdunensis* infection has been associated with healthcare-associated infection, in particular in deep-seated infections such as infective endocarditis (IE), as well as with more superficial skin and soft tissue infections.[7] However, there is relatively little data concerning *S. lugdunensis* infection in the pediatric population, with mostly isolated case reports of IE.[8–11] Most clinical guidelines for the management of *S. lugdunensis* infection are therefore based on data concerning adult patients. For this reason, this study aims to address this knowledge gap to aid clinical decision-making and the development of clinical guidelines specific to the management of *S. lugdunensis* infection in the pediatric population.

The tertiary pediatric center in NHS Greater Glasgow and Clyde studied here is the largest in Scotland and houses 256 inpatient beds, providing both inpatient and outpatient care to the pediatric population of the West of Scotland. The center is situated on a campus shared with one of the largest tertiary adult centers in the United Kingdom, providing access to the entire range of medical, surgical, emergency, neonatal and critical care specialties, including state-of-the-art laboratory and diagnostic services. We retrospectively analyzed the local rates, risk factors, and demographics of *S. lugdunensis* infection in children, the local flucloxacillin resistance rates, and the genetics which underpinned resistance.

METHODS

Ethical approval

Approval from the local Caldicott Guardian for this anonymized retrospective data analysis project was obtained for data collection, analysis, and publication.

Cohort selection

A retrospective analysis of all *S. lugdunensis* isolates across a 6-year period from 2015 to 2020 was undertaken. Data was collected for each patient from electronic patient notes as well as laboratory records. Data collected included basic demographic data: C-reactive protein (CRP) level, white blood cell count level, the reason for admission, isolate sources, isolate susceptibilities, antibiotics prescribed (if any), length of the course, length of admission, if microbiological advice was given (and if so, if the advice was followed), patient outcome, and reference laboratory results (if applicable).

Data from 2015 onwards were collected as this was when the local microbiology lab first used matrix-assisted laser desorption ionization and time of flight mass spectrometry (MALDI-TOF-MS) technology, which has only come into widespread use in recent years. Prior to this, accurate identification of CoNS was challenging and relied primarily on biochemical assays.

Accurate identification of clinical infection versus colonization was ascertained through the clinical and microbiology laboratory notes, as well as reviewing inflammatory markers. Isolates were deemed to be infection-causing where patients had clinical signs and/or symptoms in keeping with infection and/or raised white cell count or CRP. Where isolates were identified in patients without signs, symptoms, or hematological/biochemical signs of infection, the isolates were classified as colonization. In all cases, the retrospective analysis of this data aligned with the clinical interpretation of positive cultures at that time.

Statistical analysis

Data analysis was patient-centric rather than isolate-centric, as a number of patients had two or more positive isolates of *S. lugdunensis*. This meant each patient was included only once in the data analysis. Graphpad Prism 9 was used for statistical analysis. Where appropriate, odds ratios (OR) with 95% confidence intervals were calculated. Fisher's exact test was employed as the sample size was small.[12] A P-value < 0.05 was deemed statistically significant.

RESULTS

Demographics

Ninety-six isolates of *S. lugdunensis* were identified from 86 patients between 2015 and 2020. Of these, 34 isolates were deemed to be clinically significant and treated as infection. Figure 1 illustrates the age of all patients with a positive *S. lugdunensis* isolate, compared to the ages of patients with *S. lugdunensis* infection. Most positive isolates (54.7%) were identified in patients under the age of 1 year. On subgroup analysis of 47 patients under the age of 1 year, it was found that all seven patients who had no complications from birth isolated *S. lugdunensis* within the first 7 days of life. Of the 40 patients who were either premature or who experienced complications from birth, 13 (32.5%) isolated *S. lugdunensis* in the first 7 days of life compared with 27 (67.5%) thereafter.

The age distribution of *S. lugdunensis* infection appeared to be bimodal, with incidence peaking in both infancy and teenage years (Figure 1B). Age over 11 years of age was

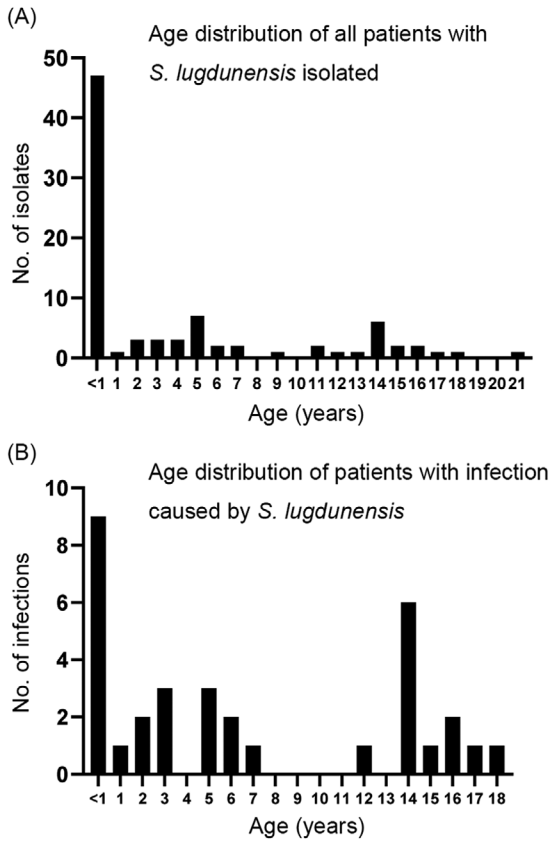

FIGURE 1 (A) Age distribution of all patients with *S. lugdunensis* isolate. (B) Age distribution of patients with *S. lugdunensis* infection.

linked to higher odds of *S. lugdunensis* infection (OR: 8.91, 95% confidence interval [CI]: 2.32, 31.08; $P < 0.05$) (Table 1).

Of the 86 patients identified with *S. lugdunensis* isolates, 42 (48.8%) were male and 44 (51.2%) were female. Of those with *S. lugdunensis* infection, 15 (44.1%) were male and 19 (55.9%) were female. There was no statistically significant difference between males and females with *S. lugdunensis* colonization or infection ($P = 0.51$).

Infection source

Of the 34 isolates of *S. lugdunensis* deemed to be infection, 23 (67.6%) were skin infections. This was reflected in non-infection-causing isolates, where 34/52 (65.4%) isolates were also from skin swabs.

Whether the isolate was grown from a sterile site or not seemed to influence whether the isolated was treated as an infection or contaminant: sterile site samples were significantly more likely to be considered infections than non-sterile site samples (OR: 5.82, 95% CI: 1.97, 16.14; $P < 0.05$). Of sterile site samples, three samples of cerebrospinal fluid cultured *S. lugdunensis*. All three isolates were associated with ventriculoperitoneal (VP) shunts and were clinically deemed infections rather than colonization. Statistical analysis was not performed on this subgroup due to the small size of the group.

The third major source of infection was intraabdominal, where 3/5 cultures of *S. lugdunensis* were deemed to be infection; the remaining two were regarded as contaminants. There was no significant difference between infection and contamination (OR: 2.42, 95% CI: 0.47, 14.07; $P = 0.38$) (Table 1).

Past medical history

Forty patients had no significant past medical history recorded. Patients with any significant past medical history were not at any increased risk of *S. lugdunensis* infection (OR: 1.43, 95% CI: 0.59, 3.24; $P = 0.51$). Subgroup analysis found no significant difference in patients with cardiac, dermatological, central nervous system (CNS), intraabdominal, urinary, hematological, or respiratory past medical history and *S. lugdunensis* infection. However, significant musculoskeletal past medical history did seem to be a risk factor for *S. lugdunensis* infection: all four patients with a musculoskeletal past medical history and *S. lugdunensis* isolated were clinically deemed to have *S. lugdunensis* infection (Table 1).

Local flucloxacillin resistance rates and prescribing patterns

Overall, rates of flucloxacillin-resistant *S. lugdunensis* infection were low in Greater Glasgow and Clyde: 16/86 (18.6%) of isolates from unique patients were found to be resistant. This broke down to 8/52 (15.4%) cases where *S. lugdunensis* was deemed to be a contaminant or colonization, and 8/34 (23.5%) cases with *S. lugdunensis* was considered an infection. There was no statistically significant difference in flucloxacillin resistance rates between infection and non-infection isolates (Table 1).

Flucloxacillin was the most prescribed antibiotic in *S. lugdunensis* infection, accounting for 13/31 prescriptions. However, this is a somewhat surprisingly low number, given twice that number (26/34) of isolates were susceptible to flucloxacillin. A wide range of other antibiotics was prescribed in the remainder of cases, of which the most common were vancomycin (4/31) and co-amoxiclav (4/31), with the remainder accounting for one or two prescriptions each. Of note, no antibiotics were prescribed in one case (which was managed with incision and drainage of abscess only) and no specific antibiotics were documented in the medical notes in two cases (Figure 2). Only one flucloxacillin-resistant *S. lugdunensis* isolate was sent to the local reference lab for analysis. This isolate was positive for the *mecA* gene.

TABLE 1 Demographic and clinical characteristics of children with *Staphylococcus lugdunensis* infection and contamination/colonization

Variables	Infection ($n = 34$)	Contaminant or colonization ($n = 52$)	Odds ratio	*P*
Age (years)			8.91	<0.05
<11	22	49		
>11	12	3		
Sex			0.73	0.51
Male	15	27		
Female	19	25		
Sterile site			5.82	<0.05
Yes	13	5		
No	21	47		
Central nervous system source			–	–
Yes	3	0		
No	31	52		
Intraabdominal source			2.42	0.38
Yes	3	2		
No	31	50		
Skin and soft tissue source			1.12	>0.99
Yes	23	34		
No	11	18		
Past medical history			1.43	0.51
No	14	26		
Any	20	26		
Musculoskeletal medical history			–	–
Yes	4	0		
No	30	52		
Susceptibility to flucloxacillin			0.59	0.40
Sensitive	26	44		
Resistant	8	8		

–, not applicable.

Patient outcomes

One patient out of the 86 identified with *S. lugdunensis* isolated did not survive the admission to the hospital. In this case, however, *S. lugdunensis* was isolated from nasogastric tube aspiration and was deemed not clinically significant and therefore a likely contaminant or colonization. This patient died from reasons unrelated to *S. lugdunensis*.

Case reviews of all other patients highlighted two instances of recurrent infections, both of which were determined to be clinically significant isolates. The first case was of recurrent surgical wound infection in a patient who underwent cardiac surgery. *S. lugdunensis* in this case was found to be resistant to flucloxacillin. The infection resolved following a 14-day course of linezolid. The second case of recurrent *S. lugdunensis* infection was of meningitis associated with a VP shunt. This isolate was also found to be resistant to flucloxacillin. The patient was therefore managed with an initial course of intravenous vancomycin and ceftriaxone for 15 days, with the shunt being removed and replaced by an external ventricular drain (EVD). The patient was discharged after a prolonged admission, however, was readmitted shortly after with recurrent *S. lugdunensis* meningitis. On this occasion, the patient was managed with a 4-week course of rifampicin and teicoplanin, which was achieved with VP shunt removal and replaced by an EVD. The patient survived to discharge and has been followed up closely in the years since, with no long-term sequelae of *S. lugdunensis* infection having yet manifested.

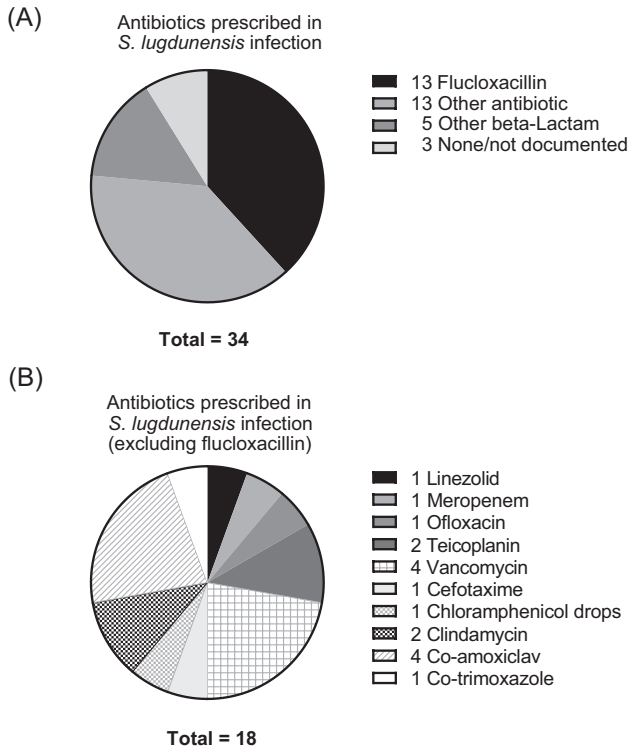

FIGURE 2 (A) Summary of antibiotics prescribed for *S. lugdunensis* infection. (B) Non-flucloxacillin antibiotics prescribed.

S. lugdunensis bacteremia

S. lugdunensis was isolated from blood cultures on eight occasions from six patients, with one patient growing *S. lugdunensis* in blood cultures three times. Two of the six cases were treated as clinically significant bacteremia, three were regarded as contaminants. The final case was regarded as a contaminant unless further isolates of *S. lugdunensis* were identified. Two additional *S. lugdunensis* positive cultures were grown from the patient's indwelling lines, however, this was not clinically managed for *S. lugdunensis* bacteremia and antibiotics were discontinued after 3 days.

The two patients who were managed clinically for *S. lugdunensis* bacteremia both had flucloxacillin-resistant *S. lugdunensis*. The patients were therefore managed with intravenous vancomycin or intravenous teicoplanin for 14 and 10 days, respectively. Both these patients had protracted admission lengths of 46 and 45 days, respectively. All six patients survived admission to discharge, and none developed any long-term sequelae of *S. lugdunensis* bacteremia such as IE or abscess formation (Table 2).

DISCUSSION

A significant proportion of *S. lugdunensis* infections identified were in patients with no past medical history (41.2%). This is comparable to the rate in all patients identified, where 46.5% had no past medical history. This reflects high colonization rates of *S. lugdunensis*–up to 50% of individuals carry *S. lugdunensis*.[13] The high incidence of *S. lugdunensis* isolates in patients with no clear infection supports this high rate of colonization. Indeed, 47/86 patients were in the neonatal intensive care unit, accounting for the significant number of patients < 1 year old identified. *S. lugdunensis* was isolated in the first 7 days of life from all the infants without complications from birth, possibly reflecting early community colonization. This compares with 67.5% of patients with complications from birth isolating *S. lugdunensis* after the first 7 days of life, reflecting iatrogenic colonization due to relatively prolonged and intensive medical contact.

A skin commensal, *S. lugdunensis* is frequently associated with skin and soft tissue infection (SSTI).[14–17] SSTI was the main source of infection identified in this study. An analysis of *S. lugdunensis* infections in adults largely reflects these findings in children, with abscesses, wound infections, and paronychias as the dominant sources of infection.[15] However, while Bocher et al.[15] identified otitis externa as the most common site of pediatric *S. lugdunensis* infection, only one case of otitis externa was identified in this study. This may, however, be due to CoNS not usually being reported as a significant organism in otitis externa. More recently, otitis media has been identified as a source of *S. lugdunensis* infection in children.[17] *S. lugdunensis* has been highlighted as a cause of necrotizing fasciitis, underlining its pathogenicity.[18] However, this current study did not identify any cases of *S. lugdunensis* necrotizing fasciitis in children.

Patients with a musculoskeletal past medical history appear to be at higher risk of *S. lugdunensis* infection. All four patients in this subgroup were managed clinically for infection. *S. lugdunensis* is an emerging cause of metalwork-associated infection[19] and periprosthetic joint infection.[20] The shorter median delay between surgery and infection than *S. aureus* underlines the high virulence of *S. lugdunensis*.[20] Aggressive source control and prolonged antimicrobial courses improve outcomes for patients with *S. lugdunensis* periprosthetic joint infection.[21]

S. lugdunensis is capable of producing biofilm, enhancing its ability to cause IE.[22,23] IE may have an incidence of up to 50% in the adult population with *S. lugdunensis* bacteremia.[24] A recent study found that 11/74 (15%) of patients across an 8-year period with *S. lugdunensis* bacteremia developed IE.[25] However, Sato et al.[26] found no cases of *S. lugdunensis* bacteremia-associated IE in children. We did not identify a single case of endocarditis in this study. There may be several reasons for this such as a relatively low sample size of true infections caused by *S. lugdunensis*. Furthermore, while *S. lugdunensis* is

TABLE 2 Data of patients with the growth of *Staphylococcus lugdunensis* in blood cultures

Patient	Age	Sex	CRP (mg/L)	Whole blood cell count (x10^9/L)	Reason for admission	Infection or contaminant	Flucloxacillin susceptibility	Antibiotic course	Length of hospital stay (days)
1	19 weeks	M	21	19.6	Fever	Contaminant	Sensitive	Amoxicillin, length of course not documented	2
2	17 years	M	71	0.1	Bone marrow transplant	Infection	Resistant	10 days teicoplanin	45
3	5 years	F	15	8.1	Fever	Contaminant	Sensitive	3 days tazocin	3
4	17 weeks	F	168	17.2	Ventricular septal defect and bronchiolitis	Infection	Resistant	14 days vancomycin	46
5	13 weeks	M	6	9.9	Respiratory syncytial virus bronchiolitis and *Staphylococcus aureus* bacteremia	Contaminant	Sensitive	5 days cefuroxime	18
6	2 years	F	95	26.5	Urinary tract infection	Contaminant	Sensitive	Cephalexin, length of course not documented	1

Abbreviations: M, male; F, female.

well-associated with IE, it remains an uncommon pathogen. A 2010 literature review found only 67 cases across 27 articles.[27]

S. lugdunensis is an emerging cause of CNS infections, particularly in association with VP shunts.[28,29] All three cases of CNS *S. lugdunensis* infection in this study were associated with VP shunts. Azimi et al.[30] found *S. lugdunensis* to be a rare but significant cause of bacterial meningitis. Mohanty et al.[31] described *S. lugdunensis* as having a potential CNS pathogenicity similar to *S. aureus*. This study supports *S. lugdunensis* as an emerging cause of CNS infection in children, particularly in association with VP shunts.

Unlike many CoNS, *S. lugdunensis* remains generally susceptible to penicillins.[32] However, resistance patterns in *S. lugdunensis* vary significantly regionally. In Denmark, penicillin resistance rates were found to be 20%.[15] Hellbacher et al.[33] similarly demonstrated as low as 15.4% of *S. lugdunensis* isolates were resistant to penicillin in Sweden. However, resistance rates may be significantly higher elsewhere, with rates of 45% in the USA.[34] Resistance rates of up to 68.4% have been observed in the critical care setting.[35] In this analysis a flucloxacillin resistance rate of 18.6% was found across all isolates of *S. lugdunensis* in children and 23.5% of infection-associated isolates. Flucloxacillin is therefore recommended locally as a reasonable first-line antimicrobial in the non-critical care setting.

One isolate of flucloxacillin-resistant *S. lugdunensis* possessed the *mecA* gene, which is associated with methicillin resistance in *S. aureus*. This may suggest a similar mechanism of penicillin resistance in *S. lugdunensis*. Caution should, however, be applied in interpreting this finding as *mecA* carriage in *S. lugdunensis* is relatively rare compared to that of *S. aureus*.[36] There may be other mechanisms of penicillin resistance.[37,38]

This study had some limitations. One limiting factor is the low sample size. This was limited from when the local microbiology lab obtained its first MALDI-TOF-MS for reliable identification of microorganisms present. As a retrospective analysis, another limiting factor was poor documentation by clinicians. In some instances, the antibiotic prescribed or course length was not recorded.

In conclusion, this study is one of the largest carried out examining *S. lugdunensis* as a pathogen using MALDI-TOF-MS in the pediatric population. *S. lugdunensis* is an uncommon but significant cause of infection in children. While *S. lugdunensis* most commonly affects the skin and soft tissue, it has an extremely wide range of clinical manifestations, including severe CNS infection, periprosthetic infection, and endocarditis. This study has identified possible risk factors, including age over 11, significant musculoskeletal past medical history, and VP shunt placement. *S. lugdunensis* appears to be a rising cause of CNS infection in pediatrics, particularly when it is associated with VP shunts. Around 81.4% of all *S. lugdunensis* isolates in

this study were susceptible to penicillin. Flucloxacillin is therefore recommended locally as the first line antibiotic of choice for *S. lugdunensis* infection. A larger, multicentre, prospective analysis may be beneficial in understanding patterns of infection in *S. lugdunensis* in the wider pediatric population. Further work could also be directed at understanding the mechanisms underpinning *S. lugdunensis* resistance patterns and at examining the role of *S. lugdunensis* in CNS infection.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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