

# Genome Sequences of Four *Staphylococcus capitis* NRCS-A Isolates from Geographically Distant Neonatal Intensive Care Units

H. Lemriss,<sup>a</sup> S. Lemriss,<sup>b</sup> P. Martins-Simoes,<sup>c,d,e</sup> M. Butin,<sup>c</sup> L. Lahlou,<sup>a</sup> J.-P. Rasigade,<sup>c,d</sup> A. Kearns,<sup>f</sup> O. Denis,<sup>g</sup> M. Deighton,<sup>h</sup> A. Ibrahim,<sup>a</sup> F. Laurent,<sup>c,d,e</sup> S. El Kabbaj<sup>b</sup>

Biotechnology Laboratory (Medbiotech), Medical and Pharmacy School, University Mohammed V de Rabat, Rabat, Morocco<sup>a</sup>; Department of Biosecurity PCL3, Laboratory of Research and Medical Analysis of the Fraternal of Gendarmerie Royale, Rabat, Morocco<sup>b</sup>; International Centre for Research in Infectious diseases, INSERM, University of Lyon, Lyon, France<sup>c</sup>; Department of Clinical Microbiology, Northern Hospital Group, Hospices Civils de Lyon, Lyon, France<sup>d</sup>; National Reference Center for Staphylococci, Hospices Civils de Lyon, Lyon, France<sup>e</sup>; Public Health England, Colindale, London, United Kingdom<sup>f</sup>; Erasme Hospital, Université Libre de Bruxelles, Brussels, Belgium<sup>g</sup>; RMIT University, Bundoora, Victoria, Australia<sup>h</sup>

***Staphylococcus capitis* pulsotype NRCS-A was previously reported as a frequent cause of late-onset sepsis in neonatal intensive care units (NICUs) worldwide. Here, we report the whole-genome shotgun sequences of four *S. capitis* pulsotype NRCS-A strains, CR03, CR04, CR05, and CR09, isolated from Belgium, Australia, the United Kingdom, and France, respectively.**

Received 15 April 2015 Accepted 16 June 2015 Published 6 August 2015

**Citation** Lemriss H, Lemriss S, Martins-Simoes P, Butin M, Lahlou L, Rasigade J-P, Kearns A, Denis O, Deighton M, Ibrahim A, Laurent F, El Kabbaj S. 2015. Genome sequences of four *Staphylococcus capitis* NRCS-A isolates from geographically distant neonatal intensive care units. *Genome Announc* 3(4):e00501-15. doi:10.1128/genomeA.00501-15.

**Copyright** © 2015 Lemriss et al. This is an open-access article distributed under the terms of the [Creative Commons Attribution 3.0 Unported license](#).

Address correspondence to S. Lemriss, lemrisssanaa@hotmail.com.

Coagulase-negative staphylococci (CoNS) are the most frequently encountered pathogens in neonatal intensive care units (NICUs) (1). However, in the NICU setting, recent studies have indicated that methicillin-resistant *Staphylococcus capitis* might emerge as a significant pathogen, causing late-onset sepsis (LOS) in several neonatal intensive care units in France, the Netherlands, and Australia (2–4).

A study in French NICUs demonstrated the spread of a single clonal population of methicillin-resistant *S. capitis* (pulsotype NRCS-A) associated with reduced susceptibility to vancomycin, which is the first line of antibiotics used in cases of LOS. Moreover, this clone has also been recently identified in NICUs in Belgium, the United Kingdom, and Australia, suggesting a worldwide distribution (5, 6).

In this report, we present the draft genome sequences of four *S. capitis* (pulsotype NRCS-A) strains (CR03, CR04, CR05, and CR09) isolated from blood cultures from four neonates hospitalized in NICUs in Belgium, Australia, the United Kingdom, and France, respectively.

All *S. capitis* strains were grown in blood agar at 37°C, and genomic DNA was extracted using the PureLink genomic DNA kit (Invitrogen), according to the manufacturer's recommended protocol. The quantity of DNA was determined using a NanoVue Plus (HVD Lifesciences), and 1 µg of DNA was used to sequence the

whole genome of each strain. The 454-shotgun libraries were prepared from the extracted genomic DNA following GS rapid library protocol (Roche 454; Roche).

The genome sequence of each *S. capitis* strain was determined by high-throughput sequencing performed on a Genome Sequencer FLX+ system (454 Life Sciences/Roche) using FLX Titanium reagents, according to the manufacturer's protocols and instructions. *De novo* assemblies were performed using the Roche Newbler (version 2.9) software package, and the sequencing results are summarized in Table 1.

An automatic syntactic and functional annotation of the draft genome was performed using the MicroScope platform pipeline (7, 8). The syntactic analysis combines a set of programs, including AMIGene (9), tRNAscan-SE (10), RNAmmer (11), Rfam scan (12), and Prodigal software (13) to predict genomic objects that are mainly coding sequences (CDSs) and RNA genes. More than 20 bioinformatics methods were used for functional and relational analyses. The homology search was performed in the generalist databank UniProt (14) and in more specialized databases, such as COG (15), InterPro (16), PRIAM profiles for enzymatic classification (17), prediction of protein localization using TMHMM (18), SignalP (19), and PSORTb (20) tools.

The chromosome of strain CR03 (ENA accession no. CTEB01000000) contains 2,575 genes, 2,466 coding sequences

TABLE 1 Summary of genome sequencing results in the present study

<i>S. capitis</i> strain	Country source	Reads (Mb)	Fold coverage (×)	No. of contigs	Genome size (bp)	G+C content (%)	Accession no.
CR03	Belgium	141,728	30	31	2,508,352	32.81	CTEB01000000
CR04	Australia	132,280	30	38	2,512,289	32.80	CTEM01000000
CR05	United Kingdom	139,569	31	39	2,543,917	32.84	CTEO01000000
CR09	France	132,205	30	34	2,490,458	32.82	CTEL01000000

(CDSs), 4 rRNAs, and 61 tRNAs; the chromosome of strain CR04 (accession no. CTEM01000000) contains 2,566 genes, 2,457 CDSs, 4 rRNAs, and 60 tRNAs; the chromosome of strain CR05 (accession no. CTEO01000000) contains 2,624 genes, 2,508 CDSs, 4 rRNAs, and 60 tRNAs; and the chromosome of strain CR09 (accession no. CTEL01000000) contains 2,540 genes, 2,432 CDSs, 4 rRNAs, and 59 tRNAs.

**Nucleotide sequence accession numbers.** This whole-genome shotgun project has been deposited at the ENA database under the accession numbers listed in [Table 1](#). The versions described in this paper are in the first versions, under BioProject designation no. PRJEB8618.

## ACKNOWLEDGMENTS

This work was supported by a grant from the Fondation pour la Recherche Médicale (FRM) (grant ING20111223510) and by the Institut National de la Recherche Médicale (INSERM) and the French Ministry of Health. This work was also supported by a grant from the NIH for H3Africa BioNet.

## REFERENCES

- Klingenberg C, Rønnestad A, Anderson AS, Abrahamson TG, Zorman J, Villaruz A, Flægstad T, Otto M, Sollid JE, Ericson J. 2007. Persistent strains of coagulase-negative staphylococci in a neonatal intensive care unit: virulence factors and invasiveness. *Clin Microbiol Infect* 13: 1100–1111. <http://dx.doi.org/10.1111/j.1469-0691.2007.01818.x>.
- Rasigade J-P, Raulin O, Picaud J-C, Tellini C, Bes M, Grandi J, Ben Saïd M, Claris O, Etienne J, Tigaud S, Laurent F. 2012. Methicillin-resistant *Staphylococcus capitis* with reduced vancomycin susceptibility causes late-onset sepsis in intensive care neonates. *PLoS One* 7:e31548. <http://dx.doi.org/10.1371/journal.pone.0031548>.
- Van Der Zwet WC, Debets-Ossenkopp YJ, Reinders E, Kapi M, Savelkoul PH, Van Elburg RM, Hiramatsu K, Vandembroucke-Grauls CM. 2002. Nosocomial spread of a *Staphylococcus capitis* strain with heteroresistance to vancomycin in a neonatal intensive care unit. *J Clin Microbiol* 40:2520–2525. <http://dx.doi.org/10.1128/JCM.40.7.2520-2525.2002>.
- D'mello D, Daley AJ, Rahman MS, Qu Y, Garland S, Pearce C, Deighton MA. 2008. Vancomycin heteroresistance in bloodstream isolates of *Staphylococcus capitis*. *J Clin Microbiol* 46:3124–3126. <http://dx.doi.org/10.1128/JCM.00592-08>.
- Cui B, Smooker PM, Rouch DA, Daley AJ, Deighton MA. 2013. Differences between two clinical *Staphylococcus capitis* subspecies as revealed by biofilm, antibiotic resistance, and pulsed-field gel electrophoresis profiling. *J Clin Microbiol* 51:9–14. <http://dx.doi.org/10.1128/JCM.05124-11>.
- Butin M, Martins Simoes P, Lemriss H, Lemriss S, Vandenesch F, Claris O, Picaud JC, Rasigade JP, Laurent F. 2014. *Staphylococcus capitis* in neonatal late-onset sepsis: unexpected worldwide dissemination of an endemic multi-resistant clone, poster 011. 5th Cong Eur Acad Pediatr Soc, 17 to 21 October 2014, Barcelona, Spain.
- Vallenet D, Belda E, Calteau A, Cruveiller S, Engelen S, Lajus A, Le Fèvre F, Longin C, Mornico D, Roche D, Rouy Z, Salvignol G, Scarpelli C, Thil Smith AA, Weiman M, Médigue C. 2013. MicroScope—an integrated microbial resource for the curation and comparative analysis of genomic and metabolic data. *Nucleic Acids Res* 41:D636–D647. <http://dx.doi.org/10.1093/nar/gks1194>.
- Vallenet D, Labarre L, Rouy Z, Barbe V, Bocs S, Cruveiller S, Lajus A, Pascal G, Scarpelli C, Médigue C. 2006. MaGe: a microbial genome annotation system supported by synteny results. *Nucleic Acids Res* 34: 53–65. <http://dx.doi.org/10.1093/nar/gkj406>.
- Bocs S, Cruveiller S, Vallenet D, Nuel G, Médigue C. 2003. AMIGene: annotation of microbial genes. *Nucleic Acids Res* 31:3723–3726. <http://dx.doi.org/10.1093/nar/gkg590>.
- Lowe TM, Eddy SR. 1997. tRNA scan-SE: a program for improved detection of transfer RNA genes in genomic sequence. *Nucleic Acids Res* 25: 955–964. <http://dx.doi.org/10.1093/nar/25.5.0955>.
- Lagesen K, Hallin P, Rødland EA, Staerfeldt HH, Rognes T, Ussery DW. 2007. RNAmmer: consistent and rapid annotation of ribosomal RNA genes. *Nucleic Acids Res* 35:3100–3108. <http://dx.doi.org/10.1093/nar/gkm160>.
- Gardner PP, Daub J, Tate JG, Nawrocki EP, Kolbe DL, Lindgreen S, Wilkinson AC, Finn RD, Griffiths-Jones S, Eddy SR, Bateman A. 2009. Rfam: updates to the RNA families database. *Nucleic Acids Res* 37: D136–D140. <http://dx.doi.org/10.1093/nar/gkn766>.
- Hyatt D, Chen GL, Locascio PF, Land ML, Larimer FW, Hauser LJ. 2010. Prodigal: prokaryotic gene recognition and translation initiation site identification. *BMC Bioinformatics* 11:119. <http://dx.doi.org/10.1186/1471-2105-11-119>.
- UnitProt Consortium. 2009. The Universal Protein Resource (UniProt) 2009. *Nucleic Acids Res* 37:D169–D174. <http://dx.doi.org/10.1093/nar/gkn664>.
- Tatusov RL, Fedorova ND, Jackson JD, Jacobs AR, Kiryutin B, Koonin EV, Krylov DM, Mazumder R, Mekhedov SL, Nikolskaya AN, Rao BS, Smirnov S, Sverdlov AV, Vasudevan S, Wolf YI, Yin JJ, Natale DA. 2003. The COG database: an updated version includes eukaryotes. *BMC Bioinformatics* 4:41. <http://dx.doi.org/10.1186/1471-2105-4-41>.
- Hunter S, Apweiler R, Attwood TK, Bairoch A, Bateman A, Binns D, Bork P, Das U, Daugherty L, Duquenne L, Finn RD, Gough J, Haft D, Hulo N, Kahn D, Kelly E, Laugraud A, Letunic I, Lonsdale D, Lopez R, Madera M, Maslen J, McAnulla C, McDowall J, Mistry J, Mitchell A, Mulder N, Natale D, Orengo C, Quinn AF, Selengut JD, Sigrist CJ, Thimma M, Thomas PD, Valentin F, Wilson D, Wu CH, Yeats C. 2009. InterPro: the integrative protein signature database. *Nucleic Acids Res* 37:D211–D215. <http://dx.doi.org/10.1093/nar/gkn785>.
- Claudel-Renard C, Chevalet C, Faraut T, Kahn D. 2003. Enzyme-specific profiles for genome annotation: PRIAM. *Nucleic Acids Res* 31: 6633–6639. <http://dx.doi.org/10.1093/nar/gkg847>.
- Sonnhammer EL, von Heijne G, Krogh A. 1998. A hidden Markov model for predicting transmembrane helices in protein sequences. *Proc Int Conf Intell Syst Mol Biol* 6:175–182.
- Bendtsen JD, Nielsen H, von Heijne G, Brunak S. 2004. Improved prediction of signal peptides: SignalP 3.0. *J Mol Biol* 340:783–795. <http://dx.doi.org/10.1016/j.jmb.2004.05.028>.
- Gardy JL, Laird MR, Chen F, Rey S, Walsh CJ, Ester M, Brinkman FS. 2005. PSORTb v.2.0: expanded prediction of bacterial protein subcellular localization and insights gained from comparative proteome analysis. *Bioinformatics* 21:617–623. <http://dx.doi.org/10.1093/bioinformatics/bti057>.