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Staphylococcus aureus colonization and risk of surgical site infection in children undergoing clean elective surgery

A cohort study

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Abstract

Staphylococcus aureus persistently colonizes the skin and nasopharynx of approximately 20% to 30% of individuals, with the highest rates in younger children. To avoid clinical problems for carriers and the spread of *S aureus* to other hospitalized patients, screening and decolonization of carriers undergoing surgery has been recommended. However, the best approach to patients undergoing clean surgery is not precisely defined. To evaluate whether children carrying *S aureus* admitted to the hospital for clean elective surgery have an increased risk of postoperative surgical infections, 393 infants and children (77.1% males; mean age ± standard deviation, 7.6 ± 4.5 years) who were scheduled for clean elective surgery procedures were evaluated for *S aureus* carriage on the day of intervention and 5 days after it. Both anterior nares and pharyngeal swabs were collected. *S aureus* was identified using the RIDAGENE methicillin-resistant *S aureus* (MRSA) system (R-Biopharm AG, Darmstadt, Germany), according to the manufacturer's instructions. At admission, 138 (35.1%) children screened positive for *S aureus*. MRSA was identified in 40 (29.0% of *S aureus* positive subjects) cases. The carriage rates of *S aureus* and MRSA varied considerably with age, and in children <2 years old the rate was significantly lower than in any other age group ($P < .05$). Surgical site infection was demonstrated in 4 out of 109 (3.7%) children who were initially colonized by *S aureus* and in 5 out of 201 (2.5%) children with a negative screening, without any statistically significant difference between groups ($P = .72$). None of these children had MRSA. These results seem to suggest that children undergoing clean elective surgery do not need to be screened for *S aureus* colonization because, although positive, they have no increased risk of surgical site infection. Following this statement, preoperative procedures should be simplified with relevant advantages from a clinical, social, and economic point of view.

Abbreviations: CDC = Centers for Disease Control and Prevention, MRSA = methicillin-resistant *Staphylococcus aureus*, MSSA = methicillin-sensitive *Staphylococcus aureus*, PCR = polymerase chain reaction.

Keywords: colonization, MRSA, MSSA, *Staphylococcus aureus*, surgical site infection

1. Introduction

Staphylococcus aureus persistently colonizes the skin and nasopharynx of approximately 20% to 30% of individuals, with the highest rates in younger children.[1] For many years, *S aureus* carriage has been known to be associated with an increased risk of developing staphylococcal infections with substantial morbidity and mortality, including surgical site infections. The importance ascribed to the problem has significantly increased in recent years because of the emergence in the community of infections caused by methicillin-resistant *S aureus* (MRSA), with its relevant treatment problems.[2] To avoid clinical problems for carriers and the spread of *S aureus* to other hospitalized patients, a study performed in adults evaluated the screening and decolonization of carriers undergoing surgery.[3] However, the efficacy of these procedures in clinical practice remains debated because several randomized controlled trials testing antibiotic nasal ointment prophylaxis to prevent postoperative *S aureus* infections have led to conflicting results.[3,4]

Several conditions (i.e., elective cardiac, orthopaedic, and neurosurgery procedures with implants) have been identified for which pre-operative screening of *S aureus* colonization and treatment of carriers is recommended.[5] However, the best approach to patients undergoing clean surgery is not precisely defined. In particular, it is unclear whether MRSA evidence should lead to a prophylactic approach different from that followed when sensitive strains are detected and data collected in children are limited. The main aim of this study was to evaluate whether children carrying *S aureus* admitted to the hospital for

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clean elective surgery have an increased risk of postoperative surgical infections.

2. Materials and methods

Infants and children scheduled for clean elective surgery procedures in the Unit of Pediatric Surgery, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy during the period June 1 to December 31, 2016, were enrolled. Clean surgery was defined according to the Centers for Disease Control and Prevention (CDC) statements.[6] Inguinal herniotomies, hydrocelotomies, orchiopexies, umbilical hernia repairs, and circumcisions were the most common operative procedures. Children with a known, chronic underlying disease and those who had been treated with antibiotics in the previous three weeks were excluded. The study protocol was reviewed and approved by the Ethics Committee of the institution where the study was performed. The parents' or legal tutors' consents were obtained before enrollment. Moreover, children ≥8 years were asked to give their written assent to participate.

At enrollment, a questionnaire was administered to collect demographic data and medical, family, and social history. Carriage of *S aureus* was evaluated on the day of the intervention and 5 days after it. Both anterior nares and pharyngeal swabs were collected. The swabbing was performed by a group of specifically trained pediatric residents supervised by a pediatrician (SE) using an ESwab kit (cat. number 480CE, Brescia, Copan, Italy). All swabs were immediately transported to a central laboratory and processed within two hours. *S aureus* was identified using the RIDAGENE MRSA system (R-Biopharm AG, Darmstadt, Germany), which is a multiplex real-time polymerase chain reaction (PCR) for the direct, qualitative detection of MRSA and its differentiation from methicillin-sensitive *S aureus* (MSSA), with 97% sensitivity and 100% specificity according to the manufacturer's declaration.[7] Sensitivity and specificity were evaluated by testing a panel of non-staphylococcal species, methicillin-sensitive coagulase-negative Staphylococci, methicillin-resistant coagulase-negative Staphylococci, borderline oxacillin-resistant *S aureus* and MSSA.[7] All tested species were found negative for MRSA.

The samples were classified as negative if there was no amplification signal but the internal control DNA was positive; MRSA if they were positive for the *mecA/mecC*, the *SCCmec/orfX* junction, and the *orfX* gene; and MSSA if they were positive for both the *SCCmec/orfX* junction and the *orfX* gene or only for the *orfX* gene. Surgical site infections were defined as superficial incisional, deep incisional, or space infection according to the CDC.[6] The emergence of a surgical site infection was monitored during the stay in the hospital and with two telephone calls 7 and 21 days after enrollment. In doubtful cases, parents were asked to bring the child to the center for control and possible therapy.

Categorical variables (i.e., gender, categories of age, swab results) are presented as frequencies and percentages. The prevalence of positive cultures was compared between subjects with or without surgical site infection using Fisher's exact test. $P < .05$ was considered statistically significant.

3. Results

A total of 393 children (77.1% males; mean age ± standard deviation, 7.6 ± 4.5 years) were enrolled (Table 1). At admission, 138 (35.1%) children screened positive for *S aureus*. Among these, 42 (33.3%), 35 (27.8%), and 49 (38.9%) children were positive only for the nasal swab, only for the pharyngeal swab, and for both swabs, respectively (12 subjects had missing values in nasal or pharyngeal swab results). MRSA was identified in 40 (29.0% of *S aureus* positive subjects) cases: 28 (77.8%) in the nose, 4 (11.1%) in the pharynx, and 4 (11.1%) in both sites. The carriage rates of *S aureus* and MRSA varied considerably with age, and in children < 2 years old, the rate was significantly lower than in any other age group ($P < .05$).

Five days after surgery, when all the children had been discharged from the hospital (more than 80% within 24 hours of admission, and the remaining in the following two days), *S aureus* colonization was evaluated in 298 (75.8%) of the initially enrolled children. Of them, 118 (39.6%), were positive for

Table 1

Sociodemographic characteristics and *Staphylococcus aureus* carriage of 393 patients with surgery, at baseline and 5 days after surgery.

Characteristic	At admission (n = 393)		At day 5 (n = 298)
Age, years	n (%)		n (%)
<2	51 (13.1)		42 (14.1)
2–4	70 (18.0)		52 (17.5)
5–9	158 (40.5)		114 (38.4)
≥10	111 (28.5)		89 (30.0)
Mean age ± SD	7.6 ± 4.5		7.6 ± 4.6
Sex			
Male	303 (77.1)		225 (75.5)
Female	90 (22.9)		73 (24.5)
S aureus carriage		Site infection after surgery (n = 9)[†]	
Negative	255 (64.9)	5/201 (2.5)	180 (60.4)
Positive	138 (35.1)	4/109 (3.7)	118 (39.6)
Nasal carriage only[*]	42 (11.0)		36 (12.3)
Pharyngeal carriage only[*]	35 (9.2)		29 (9.9)
Both[*]	49 (12.9)		47 (16.1)
MRSA positive only	40 (10.2)	0/32 (0)	44 (14.8)
Nasal carriage only[*]	28 (7.4)		26 (8.9)
Pharyngeal carriage only[*]	4 (1.1)		6 (2.1)
Both[*]	4 (1.1)		9 (3.1)

[*] The sum and percentage do not add up to the total because of 12 missing values in nasal or pharyngeal swab results at enrolment, and of 6 missing values at day 5.
[†] Follow-up information on surgery site infection was available in 310 out of 393 subjects (78.9%).

S aureus (36, 32.1%, in the nose; 29, 25.9%, in the pharynx; 47, 42.0%, in both sites; 6 subjects had missing values in nasal or pharyngeal swab results). Among *S aureus*-positive children, 44 (37.3% of *S aureus* positive subjects at day 5) were colonized with MRSA. Most of the children who were initially positive remained colonized by *S aureus* (88/107; 82.2%; 31 of the initially positive subjects had missing data at day 5), with a small increase in the number of those carrying MRSA (33/107; 30.8%). Thirty out of 191 children (15.7%; 64 of the initially negative subjects had missing data at day 5) who were previously negative were found to be colonized by *S aureus*, in some cases (11/191; 5.8%) with MRSA. Follow-up information on surgical site infection was available in 310 out of 393 children (78.9%). Surgical site infection was demonstrated in 4 out of 109 (3.7%) children who were initially colonized by *S aureus* and in 5 out of 201 (2.5%) children with a negative screening, without any statistically significant difference between groups ($P = .72$). None of these children had MRSA.

4. Discussion

In this study, carriage of *S aureus* was evaluated by monitoring both the nose and the pharynx to identify all the subjects who were colonized with this pathogen and could be considered at a potential increased risk of developing *S aureus* infection. As previously reported, the double swabbing identifies approximately 15% more carriers than those detected when only the nasal swab is used.[8] This suggests that the conclusions that can be drawn from this study are more reliable than those derived from studies that consider only nasal swabbing. Moreover, the double swabbing can, at least in part, explain why, in this study, the prevalence of *S aureus* carriage was found to increase with age, in contrast to what is reported in most studies that have evaluated colonization with *S aureus* in the general population.[1] All of these studies were performed using nasal swabbing. However, studies in which pharyngeal swabbing was used have shown that *S aureus* oropharyngeal colonization increases with age.[8] The use of double swabbing and the relevant number of school-age children enrolled in this study could have partly modified the final distribution of positivity in the different age groups.

The results seem to suggest that carriage of *S aureus,* including MRSA, is not associated with an increased risk of surgical wound infection in children undergoing clean elective surgery. Although more than one-third of the enrolled children carried the pathogen, the prevalence of surgical wound infection in the study population was low and not significantly different from that evidenced in noncolonized patients. Consequently, preoperative screening and topical antibiotic prophylaxis for the identification and eradication of *S aureus* seem to be unnecessary in these subjects, provided that the general procedures for prophylaxis of wound infection are regularly followed, as usually occurs in the center where the study was performed. This conclusion is in agreement with that drawn by Steiner et al[9] who, using the nasal swab alone, did not observe any correlation between a positive swab for *S aureus* and wound infection in children who were candidates for elective ambulatory surgery.

MRSA was found in a relevant number of cases and at a significantly higher rate than those detected in other studies regarding healthy children,[8,10] but this result was in line with that reported by Vegunta et al[11] in a study enrolling children undergoing surgery. This difference is likely related to the frequent admission to the hospital of children who finally undergo surgery. Conversely, the slight but not marginal increase in MRSA colonization evidenced in this study highlights the risk of being colonized by MRSA when children attend the hospital even for a very short period. However, colonization with MRSA did not increase the risk of *S aureus* infection in the surgical site or in other body sites, similar to that evidenced by Vegunta et al.[11] Therefore, the conclusions previously reported for *S aureus* also remain valid when MRSA alone is considered.

With reference to potential limitations of this study, a total of 393 children were initially enrolled but follow-up information on surgery site infection was available for 79% of them. Still, a sample size of 310 subjects had adequate statistical power (i.e., 80%, with alpha = 0.05) to detect an 8% difference in the proportion of surgery site infections between *S aureus* carriage groups (i.e., 2.5% of surgery site infections in *S aureus* negative subjects vs 10.5% in those positive at baseline). Assuming power = 80%, alpha = 0.05, with the results observed (i.e., 2.5% of surgery site infections in *S aureus* negative subjects vs 3.7% in those positive at baseline) a total of over 6500 subjects (i.e., over 3250 per group) would be needed. Alternatively, with 310 subjects and the results observed, power is equal to 0.09. Further, we underline that a 1.2% difference between groups is too small to be clinically relevant.

In conclusion, this study provides support that children undergoing clean elective surgery not only do not need preoperative systemic antibiotic prophylaxis but also do not need to be screened for *S aureus* colonization as they have no increased risk of surgical site infection even if they are colonized by MRSA. Although further studies on larger study population are needed to confirm our results; following this statement preoperative procedures should be simplified with relevant advantages from a clinical, social, and economic point of view.

Author contributions

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