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Original Article

Concordance between superficial swab and deep sampling in post-sternotomy mediastinitis: Single center experience☆

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ABSTRACT

Objectives: Deep sampling (DS) is the gold standard for microbiological diagnosis of post-sternotomy mediastinitis (PSM), however superficial swab (SS) are frequently performed in some centers and antibiotherapy initiated base on their results. We analysed the concordance between superficial swab and deep sampling in PSM.

Materials and methods: We analysed retrospectively patients with a PSM between 2010 and 2014 at Saint-Luc University hospital (Belgium). We considered that there was a concordance between SS and DS when the same microorganism was found in the two sampling method in each patient. Patients were stratified in six groups according to microbiology results as *Staphylococcus Aureus* (SA) sensitive or resistant, coagulase negative Staphylococcus (CoNS), Gram negative bacilli (GNB), other Gram positive bacteria (GPB) and fungi.

Results: Thirty-six patients were included. Twenty-five men (69%) and a mean age of 66 years old. The overall concordance between SS and DS was 57%. *SA* and GNB showed high concordance (100% and 85.7% respectively). For the other groups the concordance was low. The sensitivity and specificity of SS was 97% and 33% respectively. The PPV and NPV of superficial swab was 96% and 50% respectively.

Conclusion: Microbiological results from SS, even with flocked swabs, except for *SA* and GNB have low concordance with those obtained from deep sampling. Our data confirm that in PSM, deep sampling is the gold standard for microbiological assessment.

1. Introduction

Despite advances in the perioperative care and infection control practices, post-sternotomy mediastinitis (PSM), or deep sternal infection, remain a prominent cause of postoperative morbidity and mortality in cardiac surgery patients [1]. The reported incidence of PSM is between 1% and 3%, and its sequelae are associated with high mortality rates of 10%–25% [1–5]. PSM is also associated with increase length of hospital stay and additional hospital cost [1]. Risk factors are generally categorized into patient-related, operative factors, and environmental elements [1,6–13]. Perioperative prevention strategies entail modifying the patient's risk factors (diabetes, obesity, and respiratory insufficiency), preparing the patient's skin (body hair, pre-operative showering, operating site antiseptic treatment), antimicrobial prophylaxis, environmental control of the operating room and medical devices, and implementing proper surgical techniques [1]. Early diagnosis and recognition of PSM is a key factor to establish optimal management [1]. However, there is a degree of controversy around the definition of the mediastinitis that leads to a delay in the diagnosis and inappropriate clinical management. According to the definition by the hospital infection control practices advisory committee, Centers for Disease Control and Prevention (CDC), and the list of criteria for

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organ or space surgical-site infection used by the National Nosocomial Infection Surveillance system of CDC [14], Mediastinitis must meet at least one of the following criteria: Patient has organism(s) identified from mediastinal tissue or fluid by a culture or non-culture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment, for example, not Active Surveillance Culture/Testing (ASC/AST), Patient has evidence of mediastinitis on gross anatomic or histopathologic exam. Patient has at least one of the following signs or symptoms: fever (>38.0 °C), chest pain, or sternal instability and at least one of the following conditions: a) purulent drainage from mediastinal area, b)mediastinal widening on imaging test. Gram-positive cocci (coagulase-negative *Staphylococcus* (CoNS), *Staphylococcus Aureus* (SA) sensitive or resistant to methicillin) are the most common microorganisms causing PSM accounting for 60–80% of cases. A large number of microorganisms in particular other Gram positive bacilli (*Enterococcus* spp, *Streptococcus* spp), *Enterobacteriaceae* (*Escherichia coli*, *Enterobacter* spp, *Klebsiella* spp, *Proteus* spp), *Pseudomonas* or *Candida* and anaerobes have also been linked but in lesser proportions [15–17]. As soon as diagnosis of PSM is made, empiric antibiotic therapy must be initiated and include broad-spectrum coverage against methicillin-resistant Staphylococci, Gram-negative rods, and anaerobic organisms. This empiric antibiotic choice must be then adapted according to microbiology results [1]. Collection of optimal specimens for bacteriology cultures could be challenging in clinical practice [1–5]. The Gold-Standard for microbiological assessments remain perioperative deep sampling (DS), for example deep surgical biopsy (deep tissue sampling or bone biopsy) of the mediastinum [1]. However, in some centers, superficial swab (SS) samples are performed because it is easy to use and antibiotherapy is started or adapted according only on these results. The main purpose of this study was to analyze the microbiology concordance of SS compared with intraoperative DS in PSM.

2. Materials and methods

2.1. Population

This is a retrospective analysis of patients with a PSM extracted from our prospective followed cohort of patients operated in the cardiovascular department of Saint Luc University hospital (Brussels, Belgium) between January, 2010 and December, 2014. PSM was defined according to the CDC criteria [14]. All patients aged from 18 years old on, suffering of PSM, including surgical revision, with concomitant microbiological samples both SS and DS (deep tissue sample and bone biopsy) were included. Demographic (age, sex), clinical (type of operation, delay between the operation and the onset of clinical PSM) and microbiological (results from SS versus results from DS) data were recovered from our institutional database of medical record Medical explorer version 2008, V9. For Practical reasons (low numbers of some species), patients were stratified in six groups according to microbiology results as methicillin sensible or resistant *Staphylococcus aureus* (MSSA or MRSA), coagulase negative *Staphylococcus* (CoNS), Gram negative bacilli (GNB), other Gram positive bacilli (GPB) and fungi.

We consider that PSM was acute when the symptom duration was less than 30 days and chronic if longer than 30 days.

2.2. Microbiological assessment

The SS was performed using new flocked swabs (Eswabs Copan, Italy) with liquid Amies preservation medium [18,19]. The SS was performed as soon as a purulent discharge of the sternal wound was visible or when a dehiscence of the wound began appearing. Deep sampling was the intraoperative bone and deep tissues biopsies that the surgeon performed during the surgical revision for the treatment of PSM. Samples were sent rapidly to the microbiology laboratory for direct exam, aerobic and anaerobic bacterial culture including enriched media. Cultures were considered negatives if no microorganisms growing were obtained after seven days of incubation. An estimate of the concordance between the results from SS and DS cultures was provided by the percentage of DS and SS that resulted in the identification of the same pathogen in a given patient. In case of mix flora, we considered that the same microorganism found in SS and DS was concordant and the others not.

2.3. Statistical analysis

Statistical analysis was performed by using SPSS 24.0 software. Descriptive analysis was done. Chi square was used to compare the proportion of microbiological results. The statistical significance level was set at $P < 0.05$. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) was also calculated. kappa index was used to evaluate the degree of agreement between superficial swab and deep sampling techniques.

2.4. Ethical issues

Our institutional ethics committee stated that a written consent is not needed for analyses of anonymized data bases concerning data coming from routine practice, as permitted by country and European laws. Consequently, institutional ethical committee approval was granted for this study, and the committee approved this consent procedure. The institutional ethical committee give its authorisation (N° CEHF 2015/17MAR/118).

3. Results

Between 2010 and 2014, 5244 patients were operated for cardiac surgery in our institution. Among these, we found 100 suspicion of PSM (1.9%). Sixty-four patients were excluded (in 44 patient no surgery was performed, 20 only with SS see Fig. 1). Finally only thirty-six patients meet our inclusion criteria and were included in the present study (25 men (69%) with a sex ratio of 2.3) with a mean age of 66 years old. Demographic, clinical and microbiological characteristics are summarised in Table 1. Results of SS and DS showed (Fig. 2 and Table 2) that the majority of isolates were *Staphylococcus* spp (CoNS 43%, *SA* 14% in SS and CoNS 33% and SA 17% in DS). All *Staphylococcus aureus* isolates were MSSA. In SS the group of GNB included *Escherichia.coli* (n = 4), *Proteus* sp (n = 3), *Pseudomonas aeruginosa* (n = 1), *Enterobacter aerogenes* (n = 3), *Klebsiella oxytoca* (n = 1), *Citrobacter koseri* (n = 1) *Morganella morganii* (n = 3). In the Group of others GPB we found *Enterococcus faecalis* (n = 2), *Streptococcus viridans* (n = 1) and one *Candida albicans* isolate as fungi (Fig. 2 and Table 2).

The overall concordance between SS and DS was 57%. The concordance of MSSA was 100%. (Table 2). Concordance of different species belonging to GNB group are listed in Table 2. Due to low number in each of category we calculated the global concordance of GNB (85.7%, see Table 2). The concordance of CoNS, GPB and Fungi (Candida) were 66.6%, 33% and 0% respectively. The sensitivity, specificity, PPV and NPV of SS was 97%, 33%, 96% and 50% respectively. SS culture yielded one or several microorganisms (n = 46, 42 positive and 4 negative) in 36 patients. The DS cultures yielded one pathogen (n = 36, 31 positives, 5 negative) in 36 patients. For the five DS Cultures negative (3/5 patients were under antibiotherapy during the revision surgery). Value of the kappa was 39% showing poor agreement between the two tested methods of sampling.

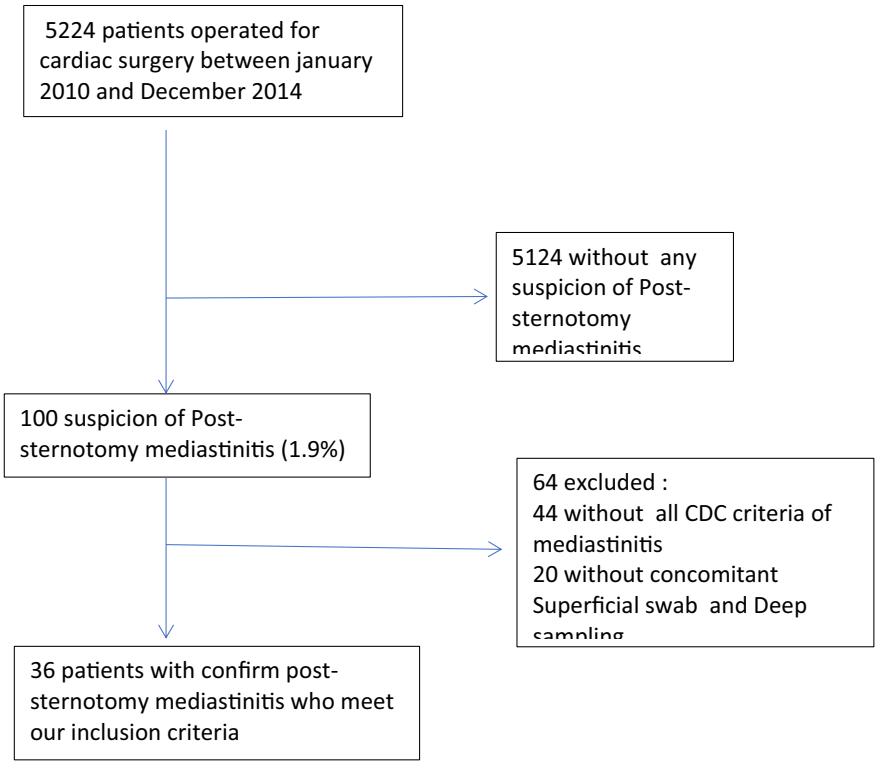

Fig. 1. Chart flow of our the study.

Table 1
Demographic, clinical characteristics of our cohort.

N	36
Average age (years)	66
Sex ratio men/women (%)	2.3 (69% men)
Type of cardiac surgery (%)	
Coronary bypass graft	13 (36)
Aortic valve surgery	6 (17)
Mitral valve surgery	3 (8)
Thoracic aorta surgery	3 (8)
Multiple surgery	8 (22)
Other	5 (14)
Presentation mode (%)	
Acute (≤30 days)	31 (86)
Chronic (>30 days)	5 (14)

4. Discussion

The main finding of this study was that the overall concordance between the microbiology results of the SS and DS specimens was low (57%). Only results concerning MSSA and GNB was high (100% and 85.7%).

Diagnosis of PSM is still challenging [1,20–23]. Taking into account the CDC criteria [14], the demonstration of infective pathogens on microbiological samples is of great importance. In our study the most frequent microorganisms found in DS were *Staphylococcus species* recovered in 50% of cases in DS (CoNS 33%, MSSA 17%). This was the case in the studies of Gardlund [24]. et al. and Cobo et al. [25]. Surprisingly was the fact that in our study DS showed monomicrobial infection. In the literature PSM are due to polymicrobial infection especially in cases of severe infection [26]. We do not have a comprehensive explanation of these results. One hypothesis can be the fact that our all consecutive cases were acute and no previous use of antibiotics. Patil et al. reported that in diabetic foot of grade 3 infection was often monomicrobial and polymicrobial infection was due to previous use of antibiotic [27]. This finding has not been reported yet in PSM.

Swabs sampling is easy to perform, but nevertheless swabs are usually recommended only for superficial wounds, oropharyngeal samples and other situations where the load of microorganisms is high or when a limited number of media should be inoculated. Therefore DS during surgery has been considered as the gold standard for microbiological assessment or diagnosis [20–23]. New flocked swabs, such as copan Eswabs used in this study, has been proven superiority to release microorganisms compared with fiber swabs and even to preserve anaerobe and fastidious microorganisms [18,19]. These new swabs could then be an alternative to DS. Our results showed overall low concordance between the SS and the DS despite the use of these flocked swabs. We can be confident only for microbiology results concerning MSSA and GNB because of their high concordance. Chaudhuri et al. study the correlation between superficial sternal swabs, blood cultures and the final culture results from deep sternal tissue in 70 patients with PSM. They found that the most common single pathogen in PSM was MSSA (n = 14) and it was found that all instances of MSSA-positive superficial swabs (n = 11), blood cultures (n = 7) or both (n = 5) predicted its growth as pure colonies from deep sternal tissue. Superficial swabs predicted the pathogen 75% of the time (n = 43). Specific to *Staphylococcus aureus* (n = 27), the positive predictive value of a superficial sternal swab was found to approach 100%. The PPV and NPV was for CoNS 69% and 91%, for GNB 70 and 98% respectively. Colonisation with multiresistant organism is 100% predictive of the pathogen in PSM [28]. Compare to our study their overall concordance between SS and DS was higher. However, as in their study, the concordance between *SA* and GNB was very high.

Our study had some limitations. Firstly, it was a retrospective study, and secondly it had a limit number of PSM. Despite these limitations, we confirm that microbiological results from SS, even

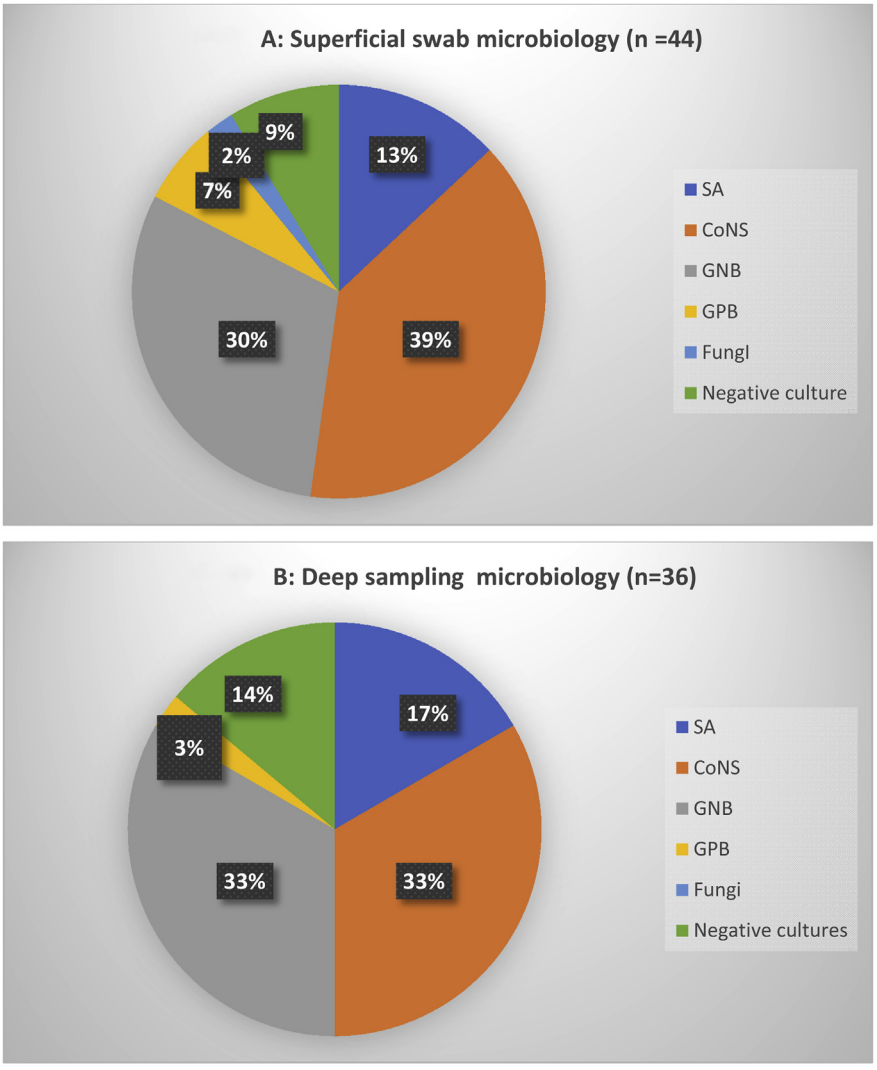

Fig. 2. A) Superficial swab microbiology results (n = 46), B) Deep sample microbiology results (n = 36). SA: *staphylococcus aureus*, CoNS: coagulase negative *staphylococcus*, GNB :gram-negative bacilli,GPB : gram-positive bacilli, Fungi(candida albicans)

Table 2
Concordance of microbiology culture results between superficial swab and deep sampling for each group of pathogens.

	Superficial swab (n = 46)	Deep sampling (DS = 36)	Concordance (%)
MSSA	6	6	100
CoNS	18	12	66
GPB	3	1	33
Enterococcus faecalis	2	1	50
Streptococcus Viridans	1	0	0
GNB	14	12	85.7%
E. Coli	4	3	66
Proteus Sp	3	3	100
Pseudomonas sp	1	0	0
Citrobacter Sp	1	1	100
Enterobacter sp	3	2	66
Klebsiella sp	1	1	100
Morganella Morgani	1	2	50
Candida albicans	1	0	0
Negative	4	5	80

MSSA: methicillin-susceptible *Staphylococcus aureus*; CoNS: Coagulase-negative *Staphylococcus*; GNB: Gram negative bacilli, GPB: Gram positive bacteria.

with flocked swabs, have low overall concordance with those obtained with DS. Our study confirm that in PSM, DS (deep tissues and bone biopsies) remain the gold standard for microbiological assessment as previously described in the literature. If superficial swab is performed, only the results for *Staphylococcus aureus* or GNB isolates can be reasonably taking into account.

Conflicts of interest

No conflict of Interest for all authors.

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