

Usefulness of Routine Epicardial Pacing Wire Culture for Early Prediction of Poststernotomy Mediastinitis

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Poststernotomy mediastinitis (PSM) is one of the most serious complications of cardiac surgery, and its associated morbidity and mortality demand early recognition for emergency therapy. In this study, we investigated the usefulness of epicardial pacing wire (EPW) cultures for the prediction of PSM. Among 2,200 patients who underwent a cardiac surgical procedure at our hospital between 1 January 1999 and 31 December 2001, 82 (3.7%) had PSM; *Staphylococcus aureus* was the organism (45.1%) most frequently isolated at the time of surgical debridement. EPWs from 1,607 (73.0%) patients, 73 (4.5%) of whom developed PSM, were cultured. EPW cultures from 466 (29.0%) were positive, most often (74.9%) for coagulase-negative *Staphylococci*. EPW cultures were truly positive in 26 cases, truly negative in 1,106 cases, falsely positive in 428 cases, and falsely negative in 47 cases (with sterile cultures in 35 cases and a culture positive for an organism different from that isolated at the time of debridement in 12 cases). EPW culture had a positive predictive value of only 5.7% and a high negative predictive value (95.9%) for the diagnosis of PSM, with an accuracy of 70.4%. However, the likelihood ratio of positive (1.27) and negative (0.89) tests indicated only small changes in pretest-to-posttest probability. Therefore, a strategy of routine culture of EPWs to predict PSM seems questionable.

Poststernotomy mediastinitis (PSM) is a life-threatening complication that occurs in about 1 to 5% of cardiac surgery procedures. PSM is associated with major patient morbidity, mortality, and cost (11). Successful management of this infection requires early diagnosis and aggressive treatment (5). In fact, the prognosis for patients with PSM appears to be related to the length of time required for the institution of treatment (4). The diagnosis of PSM is sometimes straightforward, and it is established by physical examination of the wound and by conventional laboratory studies. However, diagnosis in the early stages where treatment is the most effective is often difficult, and multiple diagnostic procedures are sometimes necessary to ascertain the infectious process.

Epicardial pacing wires (EPWs) are fixed in the pericardium at the end of cardiac surgery procedures to treat postoperative bradyarrhythmias. Some authors have suggested that EPW cultures might be helpful in the early diagnosis of PSM (2, 8, 12). However, these studies included only a small number of patients with PSM (35 patients in all). The present study was undertaken to evaluate our strategy of routine EPW culture and its contribution to identification of PSM at an early stage.

MATERIALS AND METHODS

Study population. All patients who underwent a cardiac surgical procedure via median sternotomy between 1 January 1999 and 31 December 2001 at Henri Mondor University Hospital (Créteil, France) were studied. Body hair was removed the day before operation with a clipper. Patients showered the night and

morning before surgery with a povidone-iodine solution (or chlorhexidine in case of allergy). In cases of emergency procedure, shaving and bedside washing were performed immediately before surgery. The operative site was prepared by applying an alcoholic tincture of iodine. Systemic antibiotic prophylaxis (with cefamandole or vancomycin) was initiated during anesthesia and continued 48 h postoperatively. Use of bone wax and electrocautery was left to the discretion of the operating surgeon. Internal mammary arteries were harvested as pedicles, without skeletonization. PSM was defined as a deep wound infection associated with sternal osteomyelitis, with or without infection of the retrosternal space, needing surgical debridement (6). The infection was confirmed in all cases by cultures of samples obtained during surgical debridement.

EPW culture. EPWs were removed on postoperative days 5 to 10 by sterile technique. The skin was prepared with povidone-iodine and dried with gauze. The tips (2-cm distal segments) were cut off with scissors and placed into sterile tubes. The specimens were immediately delivered to the microbiology laboratory and cultured by broth immersion. Briefly, 10 ml of brain heart infusion broth was added to the recipient tubes under sterile conditions. If any culture was detected within 48 h at 37°C, subcultures on aerobic and anaerobic agar media were performed. Bacteria were identified to the species level, and antibiograms were performed by the disk diffusion technique.

Data collection. Hospital records were reviewed retrospectively. Obesity was defined as a body weight greater than 20% of normal weight as estimated by the Lorentz formula. Diabetes was defined as the need for medication with an antidiabetic drug. Preoperative renal insufficiency was determined by serum creatinine levels higher than 1.5 mg/dl (130 μmol/liter). The incubation period duration was defined as the interval between the initial surgical procedure and reoperation for PSM.

Statistical analysis. Statistical analysis was performed with SPSS Base 10.0 statistical software (SPSS, Inc., Chicago, Ill.). Continuous variables were expressed as means ± standard deviations and were compared by an unpaired two-tailed *t* test. Categorical variables, expressed as percentages, were analyzed with a chi-square test or Fisher's exact test. A two-tailed *P* value of less than 0.05 was taken to indicate statistical significance. Standard formulas were used to calculate sensitivity [TP/(TP + FN)], specificity [TN/(TN + FP)], positive predictive value [TP/(TP + FP)], negative predictive value [TN/(TN + FN)], accuracy [(TP + TN)/(TP + TN + FP + FN)], likelihood ratio of positive test [sensitivity/(1 – specificity)], and likelihood ratio of a negative test [(1 – sensitivity)/specificity] (where TP is true-positive result, FP is false-positive result, FN is false-negative result, and TN is true-negative result).

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TABLE 1. Details of initial surgical procedure in 2,200 patients^a

Surgical detail	Value ^b
Initial procedure, <i>n</i> was:	
CABG	1,190 (54.1)
Valve replacement.....	549 (25.0)
Combined CABG plus valve replacement.....	178 (8.1)
Other.....	283 (12.9)
Mean time ± SD (min) for:	
Cardiopulmonary bypass	150.9 ± 69.7
Aortic cross-clamp.....	102.8 ± 53.6
Operation (<i>n</i>):	
Included bilateral IMA graft	41 (1.9)
Was a repeat procedure.....	285 (13.0)
Was an emergency procedure	2.4 (9.7)

^a CABG, coronary artery bypass grafting; IMA, internal mammary artery.

^b Values in parentheses are percentages.

RESULTS

Patient characteristics. Between 1 January 1999 and 31 December 2001, a total of 2,200 patients underwent a cardiac surgical procedure via median sternotomy at our hospital. The series comprised 1,627 men and 573 women, aged 64.9 ± 13.1 years (range, 14 to 95 years). Patients' mean preoperative functional status as assessed by New York Heart Association functional classification was 2.1 ± 0.8. Preoperative risk factors for mediastinitis included obesity in 276 (12.5%), diabetes in 467 (21.2%), renal insufficiency in 132 (6.0%), and chronic obstructive pulmonary disease in 155 (7.0%) patients. Details of the initial surgical procedure are presented in Table 1. A total of 1,310 (59.5%) patients received autologous blood transfusion during surgery or the immediate postoperative course; 79 (3.6%) patients needed mediastinal reexploration for postoperative bleeding or pericardial effusion.

Mediastinitis. A total of 82 patients developed PSM during the study period, for an overall incidence of 3.7%. Mediastinitis developed after a mean incubation period of 16.8 ± 10.0 days. Twelve (14.6%) patients were in septic shock at the time of surgical debridement for PSM. A total of 51 (62.2%) patients had a concomitant bloodstream infection. Patients were treated by surgical debridement associated with closed drainage with Redon catheters (3, 10) (71 patients) or other techniques (11 patients). *Staphylococcus aureus* was the pathogen most frequently responsible for PSM (37 cases, 45.1%). Organisms isolated from the sternal wound at the time of surgical debridement are listed in Table 2.

EPW culture. Figure 1 shows the results of EPW cultures in the study population. In 593 patients, wires were impossible to remove, inadvertently contaminated during the removal process, or not cultured because of admission to wards other than the cardiac surgery department. Thus, EPWs from 1,607 (73.0%) patients were cultured; 73 (4.5%) patients developed PSM. Of the 1,607 EPWs cultures obtained, 466 (29.0%) revealed organisms. Organisms isolated from the EPW cultures are listed in Table 2. Coagulase-negative *Staphylococci* was the organism most frequently isolated from EPWs (349 cultures; 74.9%).

Accuracy of EPW culture in the prediction of PSM. Table 3 reports PSM cases according to EPW cultures. Overall, EPW cultures had a sensitivity of 52.1%, a specificity of 72.1%, a positive predictive value of 8.2%, a negative predictive value of

TABLE 2. Organisms isolated from debridement material in 82 patients with PSM and 466 patients with positive EPW cultures

Organism isolated	No. (%) of organisms isolated from ^a	
	PSM wounds	EPW cultures
Gram-positive cocci		
<i>S. aureus</i>		
Methicillin sensitive	30 (36.6)	10 (2.1)
Methicillin resistant	7 (8.5)	5 (1.1)
Coagulase-negative <i>Staphylococci</i>	16 (19.5)	349 (74.9)
<i>Enterococcus</i> sp.	3 (3.7)	13 (2.8)
<i>Streptococcus</i> sp.	1 (1.2)	10 (2.1)
<i>Micrococcus</i> sp.	—	8 (1.7)
Gram-positive bacilli		
<i>Bacillus</i> sp.	—	12 (2.6)
<i>Corynebacterium</i> sp.	—	12 (2.6)
Gram-negative bacilli		
<i>Pseudomonas aeruginosa</i>	3 (3.7)	2 (0.4)
<i>Acinetobacter baumannii</i>	—	1 (0.2)
<i>Escherichia coli</i>	2 (2.4)	5 (1.1)
<i>Enterobacter</i> sp.	3 (3.7)	2 (0.4)
<i>Klebsiella pneumoniae</i>	1 (1.2)	1 (0.2)
<i>Citrobacter</i> sp.	2 (2.4)	1 (0.2)
<i>Serratia</i> sp.	2 (2.4)	—
<i>Candida</i> sp.	1 (1.2)	—
Polymicrobial spp.	11 (13.4)	35 (7.5)

^a —, organism was not isolated or cultured.

96.9%, an accuracy of 71.2%, a likelihood ratio of positive test of 1.87, and a likelihood ratio of negative test of 0.66 for the prediction of PSM. For a more precise evaluation of its accuracy, EPW cultures from patients with PSM were considered positive if the organism cultured was identical to that found at the time of surgical debridement, with the same antibiotic susceptibility. By this definition, EPW cultures were truly positive in 26 cases, truly negative in 1,106 cases, falsely positive in 428 cases, and falsely negative in 47 cases (the culture was sterile in 35 cases and positive for an organism different from that isolated at the time of debridement in 12 cases). In this setting, the value of EPW culture for the diagnosis of PSM had a sensitivity of 35.6%, a specificity of 72.1%, a positive predictive value of 5.7%, a negative predictive value of 95.9%, an accuracy of 70.4%, a likelihood ratio of positive test of 1.28, and a likelihood ratio of negative test of 0.89. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of EPW cultures for cases of PSM due to *S. aureus* and coagulase-negative *Staphylococcus* are reported in Table 4.

DISCUSSION

PSM is one of the most dreaded complications of cardiac surgery. The result of treatment largely depends on timely diagnosis, and the associated morbidity and mortality demand early recognition for emergency therapy. Pacing wires are fixed in the pericardium at the end of cardiac surgery operations and can be considered microbiological samples of the anterior mediastinum. Three previous studies have evaluated the accuracy of EPW cultures in the early prediction of PSM (2, 8, 12), but these series comprised small numbers of patients with PSM,

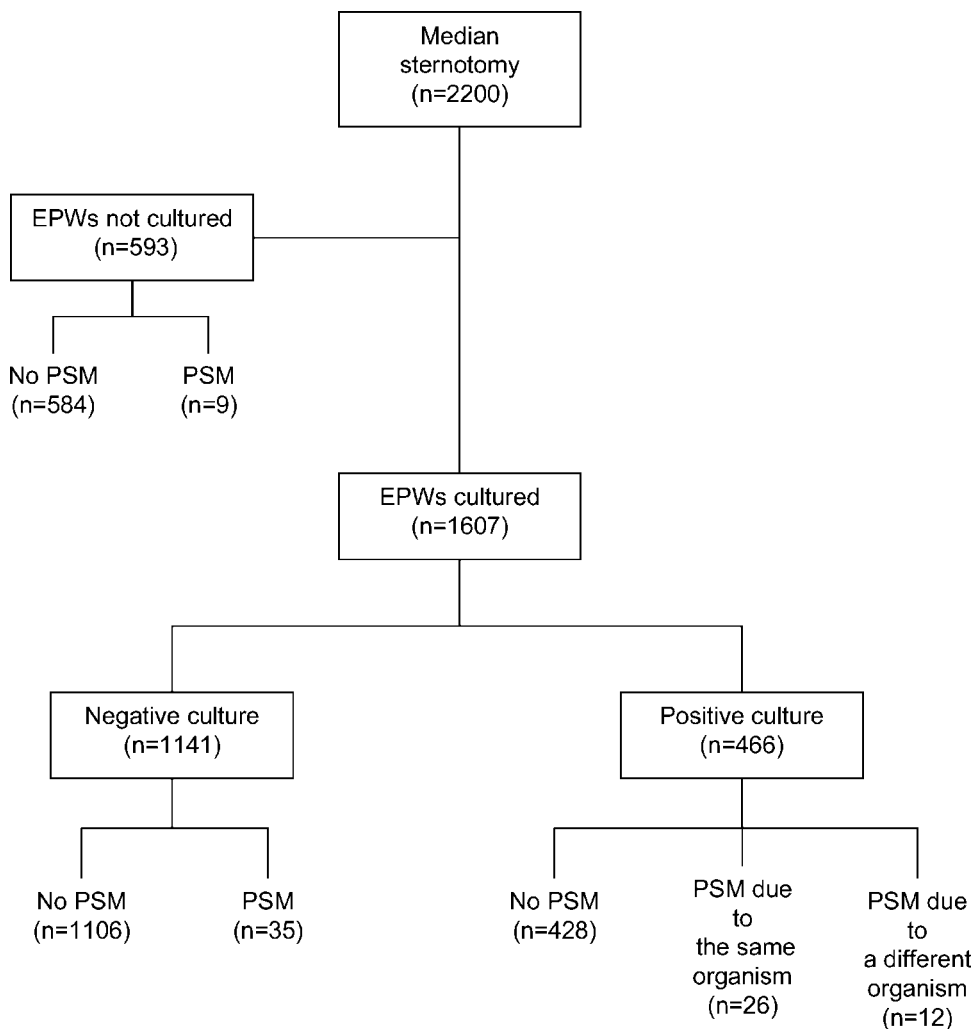


FIG. 1. EPW cultures and PSM in the study population.

mostly caused by staphylococci, and could not examine the potential value of positive EPW cultures due to organisms other than *S. aureus*.

In the present report, we investigate the accuracy of EPW culture as a diagnostic tool for PSM in a large series of patients, many of whom exhibited numerous known risk factors for mediastinitis, including obesity, diabetes, renal insufficiency, chronic bronchopulmonary disease, emergency operation, redo operation, coronary artery bypass grafting, blood transfusion, and mediastinal reexploration.

In our study, *S. aureus* was the organism most frequently found to be responsible for PSM (45.1%). These findings are in

agreement with those of other studies of postsurgical mediastinitis (7, 13). Coagulase-negative *Staphylococcus* was the main organism isolated from EPW cultures (74.9%). This pathogen, as do other members of the skin saprophytic flora, contributed to the high number of false-positive results (91.8% of positive cultures). There were also a substantial number of negative cultures among patients who exhibited PSM (35 cultures; 47.9%). A possible explanation for these cases could be that EPWs were removed before the onset of PSM or after antibiotic treatment was started.

The sensitivity and positive predictive value of EPW culture were very low in this study, while the negative predictive value was high (95.9%). A negative EPW culture could therefore constitute an argument against the diagnosis of PSM. This could help clinicians avoid costly diagnostic investigations and unnecessary mediastinal reexplorations associated with increased morbidity and prolonged hospital stays. Furthermore, in a patient with postoperative sepsis, a negative EPW culture should encourage a search for other potential sources of infection. Maroto et al. also reported a high negative predictive value (99.1%) of EPW cultures for the diagnosis of PSM (12).

TABLE 3. PSM in patients whose EPWs were cultured

EPW culture	Patients without PSM	Patients with PSM	Total
Negative	1,106	35	1,141
Positive	428	38	466
Total	1,534	73	1,607

TABLE 4. Value of EPW cultures in the diagnosis of PSM due to *S. aureus* and coagulase-negative *Staphylococcus*

PSM due to:	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	% Accuracy
<i>S. aureus</i>	29.0	99.6	60.0	98.6	98.3
CNS ^a	50.0	78.6	2.3	99.4	78.3

^a CNS, coagulase-negative *Staphylococcus*.

When PSM was due to *S. aureus*, the negative predictive value in their study reached 99.6%. In our series, the negative predictive value of EPWs cultures was 98.6% when only PSM caused by *S. aureus* was considered. However, the low rate of infection may contribute to the high negative predictive value of the test. In fact, despite providing a direct assessment of the usefulness of a test in clinical practice (1), predictive values are highly dependent on the prevalence of the abnormality in the specific population studied, as shown by Bayes' theorem. By contrast, the likelihood ratios are thought of as being less dependent on disease prevalence. In our series, the likelihood ratios of EPW cultures were between 0.5 and 2, indicating only small changes in the posttest probability of PSM (9). Thus, it seems questionable whether a strategy of routine culture of EPWs is likely to produce a significant diagnostic gain.

In summary, a positive EPW culture does not appear to be a useful tool for the early diagnosis of PSM. A negative culture could help rule out a clinical suspicion of PSM, but the result generates only small shifts in pretest-to-posttest probability.

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