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Efficiency of Antibacterial Suture Material in Cardiac Surgery: A Double-Blind Randomized Prospective Study

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ABSTRACT

Objective: Postoperative surgical site infections (SSI) still greatly affect mortality and morbidity in cardiovascular surgery. SSI may be related to the suture material. In this prospective, randomized, controlled, and double-blinded study, the effect of antibacterial suture material on SSI in cardiac surgical patients was investigated.

Methods: We randomly allocated 510 patients into 2 groups. Antibacterial suture materials were used for wound closure in 170 patients (triclosan-coated suture group), and routine suture materials were used in 340 patients (noncoated suture group). All patients were evaluated for SSI on days 10, 20, and 30 following cardiac surgery.

Results: Preoperative risk factors and laboratory findings were comparable for the 2 groups. Sternal infection occurred in 4 (2.4%) of the patients in the triclosan-coated suture group and in 3.5% of the noncoated suture group ($P > .05$). Leg wound infection occurred in 5 (3.5%) of the patients in the triclosan-coated suture group and in 3.8% of the noncoated suture group ($P > .05$). Only diabetes mellitus was an independent predictor of SSI.

Conclusion: Both noncoated and triclosan-coated suture materials are safe. Larger studies may be needed to show the benefit and cost-effectiveness, if any, of triclosan-coated materials over noncoated materials.

INTRODUCTION

Postoperative surgical site infection (SSI) remains a major source of illness and, less frequently, a cause of death in the surgical patient. These infections number approximately 500,000/year among an estimated 27 million surgical procedures in the United States [Mangram 1999; Nichols 2001; Gårdlund 2007]. Infections lead to longer hospitalization times and higher costs [Mangram 1999; Nichols 2001]. In addition, SSI complicating coronary artery bypass grafting procedures are significant in terms of morbidity, mortality, and economic impact [Mangram 1999; Gårdlund 2007]. Sternal and leg wound infections are major complications after cardiovascular surgery in terms of their morbidity and increased costs [Olsen 2002, 2003; Fleck 2007]. Following cardiac surgeries, the incidence is approximately 0.7% to 4% for sternal wound infection, 0.25% to 4% for mediastinitis, and 6% to 8% for leg wound infection [Harrington 2004; Finkelstein 2005].

Suture materials may be related to SSI [Mingmalairak 2009]. In recent years, a new antimicrobial suture (polyglactin 910 coated with triclosan [Vicryl Plus; Ethicon, Somerville, NJ, USA]) has been introduced to the market. Triclosan is a broad-spectrum antiseptic that has been widely used in humans for more than 30 years [Slater-Radosti 2001; Escalada 2005]. In the beginning, the mode of action was thought to be via nonspecific disruption of the bacterial cell membrane; however, new studies have revealed the target of triclosan to be the Fab 1 gene, which blocks bacterial fatty acid synthesis. It has antimicrobial activity against Staphylococcus aureus, S epidermidis, methicillin-resistant S aureus (MRSA), methicillin-resistant S epidermidis (MRSE), vancomycin-resistant enterococci (VRE), Pseudomonas aeruginosa, and Escherichia coli [Slater-Radosti 2001; Escalada 2005]. Many studies have reported clinical use of this suture in animal models. There has been no evidence of carcinogenic potential, genotoxicity, or skin-sensitization potential in animal model studies [Barbolt 2002; Storch 2002; Marco 2007]. Studies that have investigated the effects of these suture materials on infections have found positive effects with respect to preventing infections [Fleck 2002; Ford 2005; Leonardo 2006; Rozzelle 2008; Justinger 2009] or found benefits similar to those of other materials [Mingmalairak 2009].

The aim of this study was to evaluate whether the incidence of sternal and leg wound infections is reduced when coated sutures are used for wound closure, compared with noncoated sutures.

MATERIALS AND METHODS

We designed a prospective, randomized, controlled, double-blind, comparative single-center study to evaluate the

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Table 1. Preoperative Demographic and Other Characteristics of the Control and Study Groups*

	Study Group, n (%)	Control Group, n (%)	P
Age			.924
< 65 y	100 (58.8)	202 (59.4)	
> 65 y	70 (41.2)	138 (40.6)	
Sex			.620
Male	110 (64.7)	228 (67.1)	
Female	60 (35.3)	112 (32.9)	
Diabetes mellitus			.767
Yes	57 (33.5)	120 (35.3)	
No	113 (66.5)	220 (64.7)	
Smoking			.129
Yes	49 (28.8)	77 (22.6)	
No	121 (71.2)	263 (77.4)	
Type of operation			.104
Elective	168 (98.8)	326 (95.9)	
Emergency	2 (1.2)	14 (4.1)	
Operation			.078 (^{2} = 6.808)
CABG	147 (86.5)	263 (77.4)	
Valve repair	17 (10.0)	50 (14.7)	
CABG and valve repair	6 (3.5)	25 (7.4)	
Other operations	0 (0.0)	2 (0.6)	
Duration of operation			.382
< 3 h	145 (85.3)	279 (82.1)	
> 3 h	25 (14.7)	61 (17.9)	
EuroSCORE risk score			.077
< 5	119 (70.0)	210 (61.8)	
> 5	51 (30.0)	130 (38.2)	
Body mass index			800 (^{2} = 0.446)
< 25 kg/m^2	45 (26.5)	98 (28.8)	
25-30 kg/m^2	84 (49.4)	158 (46.5)	
> 30 kg/m^2	41 (24.1)	84 (24.7)	

*The study and control groups are the triclosan-coated and noncoated suture groups, respectively. CABG indicates coronary artery bypass grafting.

efficacy of polyglactin 910 suture coated with triclosan (Vicryl Plus) for reducing the SSI of cardiac surgery, compared with traditional polyglactin 910 suture (Vicryl). On the assumption that the SSI incidence would be reduced from 6% to 1%, a study population consisting of 510 patients (170 test individuals and 340 control individuals) was created, with the sample group being one half the size of the control group in the power analysis, which was performed with a risk coefficient (α) of 0.05, a confidence interval ($1 - \alpha$) of 0.95, a risk coefficient (β) of 0.20, and a power ($1 - \beta$) of 0.80. The study universe comprised patients undergoing cardiac surgery in a private hospital in Istanbul, Turkey. From April 2008 to September 2009, 510 patients underwent a cardiac surgical procedure. Of these patients, 340 patients underwent conventional wound closure with polyglactin 910 suture (Vicryl), and 170 patients underwent wound closure with Vicryl Plus Antibacterial. This prospective study was approved by the Marmara University Faculty of Medicine and Private Hospital ethics boards.

Table 2. Differences between the Study Group (n = 170) and the Control Group (n = 340) with Regard to Preoperative Laboratory Findings*

Laboratory Parameter	Study Group	Control Group	P
Hemoglobin, mg/dL	13.30 ± 1.73	13.55 ± 1.78	.124 (t = 1.539)
Hematocrit, %	39.22 ± 5.60	39.97 ± 4.90	.124 (t = 1.540)
BUN, mg/dL	19.40 ± 9.58	18.87 ± 7.39	.489 (t = 0.692)
Creatinine, mg/dL	0.89 ± 0.31	0.87 ± 0.25	.450 (t = 0.756)
AST, U/L	24.85 ± 12.65	26.81 ± 21.54	.274 (t = 1.095)
ALT, U/L	25.59 ± 20.08	30.87 ± 49.00	.178 (t = 1.350)
Blood glucose, mg/dL	121.06 ± 50.85	119.33 ± 43.65	.691 (t = 0.398)

*Data are presented as the mean ± SD. The study and control groups are the triclosan-coated and noncoated suture groups, respectively. BUN indicates blood urea nitrogen; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

Table 3. Development of Sternum and Leg Site Infections in the Control and Study Groups*

	Study Group, n (%)	Control Group, n (%)	Total, n (%)	P
Development of sternun site SSI				.596 (^{2} = 0.516)
Yes	4 (2.4)	12 (3.5)	16 (3.1)	
No	166 (97.6)	328 (96.5)	494 (96.9)	
Total	170 (100.0)	340 (100.0)	510 (100.0)	
Development of leg site SSI				1.000
Yes	5 (3.5)	10 (3.8)	15 (3.7)	
No	137 (96.5)	250 (96.2)	387 (96.3)	
Total	142 (100.0)	260 (100.0)	402 (100.0)	

*Both sternal infection and leg infection developed in 3 patients. The study and control groups are the triclosan-coated and noncoated suture groups, respectively. SSI indicates surgical site infection.

Patient details, including demographics, physical and laboratory findings, habits, and chronic disease status, were collected with patient identification forms. Patients were assessed according to the preoperative EuroSCORE risk-rating system. Suture materials were delivered to the surgeon by the operation nurse during the operation, with the patients sequentially randomized with respect to which suture material would be used. Patients were inspected daily by a skilled nurse for any wound discharge, exudates, wound integrity, swelling, redness, pain, sensitivity, and signs of inflammation. The infection was diagnosed according to the criteria of the US Centers for Disease Control and Prevention. In cases of a suspected wound, swabs for cultures were taken, and the cardiac surgeon was called for evaluation and potential surgical revision. After discharge, all patients were evaluated in the cardiac rehabilitation department every 10 days for 1 month after surgery. All data were collected and coded prospectively and were analyzed with SPSS software (version 11.5 for Windows; SPSS, Chicago, IL, USA). Descriptive statistics were presented as the mean and SD, and as the frequency and percentage. Continuous variables were compared with the independent Student t test, and the chi-square test was used to compare proportions for the 2 groups. Univariate analysis and multivariate logistic regression analyses were used to determine predictors for SSI. A P value <.05 was considered statistically significant.

RESULTS

Table 1 summarizes the demographic and preoperative characteristics of the patients in the coated and noncoated suture groups in our study. Laboratory findings are summarized in Table 2. Patients in the coated and noncoated suture groups were similar with regard to demographics and laboratory values. The mean age of the patients in the coated suture group was 60.15 ± 10.77 years, and the mean age for the noncoated suture group was 61.21 ± 10.25 years (P > .05). During the study, the overall SSI rate in the noncoated and coated suture groups was 5.4%. In the coated suture group, sternal wound infection developed in 4 patients, and leg wound infection developed in 5 patients. In the noncoated suture group, sternal wound infection developed in 12 patients, and leg wound infection developed in 10 patients. Both sternum and leg wound sites of infection occurred in 3 patients (Table 3). All sternal infections were superficial, such that no patient developed mediastinitis requiring revision. The microorganisms isolated from the patients who developed sternum and leg infection in the coated and noncoated suture groups are provided in Table 4. The risk factors present in patients with and without infection are shown in Table 5. No significant difference was found between the patients with and without infection in both groups with respect to sex, body mass index, smoking, type of operation, and presence of distant infection (P > .05). The incidence of SSI in patients with diabetes was 3.23 times higher than in patients without diabetes (P = .04; 95% confidence interval, 1.45-7.23) (Table 6).

Table 4. Distribution of Wound Culture Results for Surgical Site Infections (SSI) in the Study and Control Groups*

	Study Group, n (%)		Control Group, n (%)	
Culture Results	Sternum Site	Leg Site	Sternum Site	Leg Site
Staphylococcus aureus	—	—	4 (50.0)	1 (50.0)
S epidermis	1 (25.0)	—	1 (12.5)	1 (50.0)
Candida albicans	—	—	1 (12.5)	—
Corynebacterium ssp	—	—	1 (12.5)	—
Pseudomonas aeruginosa	1 (25.0)	—	—	—
Klebsielle pneumonaie	1 (25.0)	2 (100.0)	—	—
Not detected	1 (25.0)	—	1 (12.5)	—
Total	4 (100.0)	2 (100.0)	8 (100.0)	2 (100.0)

*The study and control groups are the triclosan-coated and noncoated suture groups, respectively.

DISCUSSION

Postoperative SSI still greatly affects mortality and morbidity in cardiac surgery [Mangram 1999; Nichols 2001; Gårdlund 2007]. We investigated the effect on SSI of the use of antibacterial (triclosan-coated) suture material in cardiovascular surgery. The overall rate of infection in the coated and noncoated suture groups of patients in our study was 5.4% (n = 28). In our study, SSI developed in 9 (5.3%) of the patients in the coated suture group and in 19 (5.6%) of the patients in the noncoated suture group (P > .05). Studies conducted on this subject have found an SSI rate of 4.3% in pediatric patients who underwent shunt surgery with antibacterial suture material, whereas the rate was 21% in patients in whom antibacterial suture material was not used [Rozzelle 2008]. These materials can be used for reducing the rate of SSI [Leonardo 2006; Fleck 2007]. The rate of SSI was 4.9% in a group of patients who underwent abdominal surgery with antibacterial suture material, and the rate was 10.8% in the group of patients who underwent their surgeries without the use of antibacterial sutures [Justinger 2009]. SSI developed in 8% of the patients in whom antibacterial suture material was used and not used, and those materials can be used in patient groups at risk [Mingmalairak 2009]. The lower infection rate in our study compared with other studies may be because our study was not conducted in a training hospital and all procedures were performed by specialist physicians.

In our study, the overall rate of sternal infection was 3.1% (n = 16), a rate between the 1.9% and 5.1% range of rates reported in the literature [Olsen 2002; Ku 2005]. In our study, the rate of sternal wound infections was lower than that of other studies. In the study hospital, patients who have undergone cardiac surgery and have not experienced an infection problem during the follow-up are discharged on day 5. An experienced nurse specialized in cardiac rehabilitation provided all patients with discharge training on wound care and follow-up, and training follow-up was made. The social culture infrastructure of the health care provided by nurses reduces the risk of infection.

Table 5. Comparison of Some Risk Factors for the Patients Who Developed and Did Not Develop Surgical Site Infections (SSI)

Demographic Characteristic	SSI-Development Status, n (%)		P
	None	Present	
Sex			.067
Male	324 (67.2)	14 (50.0)	
Female	158 (32.8)	14 (50.0)	
Body Mass Index			348 (^{2} = 2.111)
< 25 kg/m^2	137 (28.4)	6 (21.4)	
25-30 kg/m^2	230 (47.7)	12 (42.9)	
>30 kg/m^2	115 (23.9)	10 (35.7)	
Smoking status			.823
Smoking	120 (24.9)	6 (21.4)	
Not smoking	362 (75.1)	22 (78.6)	
Type of Operation			.217
Elective	468 (97.1)	26 (92.9)	
Emergency	14 (2.9)	2 (7.1)	
Presence of distant infection			1.000
Present	2 (5.5)	0 (0.0)	
None	480 (94.5)	28 (100.0)	

In our study, sternal wound infection developed in 4 (2.4%) of the patients in the coated suture group and in 12 (3.5%) of the patients in the noncoated suture group; this difference was not statistically significant (2 = 0.516; P > .05). P aeruginosa (n = 1), S epidermidis (n = 1), and Klebsiella pneumoniae (n = 1) were isolated from the sternal region of the coated suture group with infection, and S aureus (n = 4), S epidermidis (n = 1), Candida albicans (n = 1), and Corynebacterium spp (n = 1) were isolated from the sternal region of the noncoated suture group. The microorganisms most commonly isolated from the sternal region in previous studies have included S aureus, MRSE, MRSA, S epidermidis, Enterococcus faecalis, Acinobacter, and P aeruginosa [Bhatia 2003; Harrington 2004; Ku 2005; Fleck 2007]. Moreover, previous studies have found that triclosan-coated suture materials may reduce the incidence of SSI by preventing bacterial colonization [Barbolt 2002; Storch 2002]. In the absence of sutures, SSI occurred when there were 10,000 to 100,000 colony-forming units (CFU)/mg of bacteria; however, if sutures were used, the presence of only 100 CFU/mg was capable of causing SSI [Mingmalairak 2009]. One hypothesis for this result is that the human body recognizes the suture as a foreign body. Bacteria attach to a suture and subsequently form a biofilm, which promotes attachment and interference with the immune system [Escalada 2005]. Because of the importance of sutures, suture material coated with triclosan was developed. It has antimicrobial activity against S aureus, S epidermidis, MRSA, MRSE, VRE, P aeruginosa, and E coli [Slater-Radosti 2001; Barbolt 2002; Storch 2002; Escalada 2005]. Although suture materials prevent the colonization of bacteria that promote SSI, the fact that MRSA was isolated from none of our patients suggests that the origin of the infectious agent was not the hospital and that the infection therefore originated from the patient's living space.

The overall rate of leg infection in the coated and noncoated suture groups of patients in our study was 3.7% (n = 15). Other studies have found rates of leg infection ranging between 4.5% and 4.9% [Olsen 2003; Ku 2005]. In our study, leg wound infection occurred in 5 (3.5%) of the patients in the coated suture group and in 10 (3.8%) of the patients in the noncoated suture group. There was no significant difference between the 2 groups in the rate of leg infection (P > .05). Leg infection occurring following cardiac surgery may be due to the suture material [Swenne 2006]. In our study, the rate of leg infection was lower than in other studies. K pneumoniae grew in the leg region of 2 patients in the coated suture group, and S aureus and S epidermidis grew in 1 patient each in the noncoated suture group. One study reported that E coli is the microorganism most often isolated from patients undergoing cardiac surgery [Bhatia 2003]. Although the incidence of infection found in our study was low, the reason for isolating the microorganisms mentioned above may have been due to a break in the asepsis-antisepsis chain at a particular point, due either to unsuitable hygienic conditions in the living spaces of our patients or to incorrect practices.

A difference that approached statistical significance between the patients who developed infection and those who did not was found with respect to the patient's sex (P = .067). The literature contains reports that female sex is a predisposing factor for the development of SSI in patients undergoing

Table 6. Effects of Independent Variables on the Surgical Site Infection (SSI) according to Multivariate Logistic Regression Analysis*

Independent Variable	Odds Ratio	95% CI	P
Age > 65 y	1.22	0.53 – 2.78	.637
Sex	1.76	0.79 – 3.92	.161
Diabetes mellitus	3.23	1.45 – 7.23	.04†
Type of operation	2.84	0.56 – 14.31	.204
Preoperative hospitalization > 5 d	0.98	0.91 – 1.05	.164
EuroSCORE > 5	1.74	0.75 – 4.03	.196

*CI indicates confidence interval.

†Statistically significant (P < .05).

cardiac surgery [Bhatia 2003; Ku 2005; Rogers 2006; Swenne 2006]. Our finding is consistent with that literature.

In our study, 362 (75.1%) of the patients without occurrence of infection and 22 (78.6%) of patients with occurrence of infection were nonsmokers, and no significant difference was found between the 2 groups in terms of smoking (P > .05). The effect of nicotine on SSI is also a controversial issue in the literature [Mangram 1999; Bhatia 2003; Ku 2005]. The lack of any significant relationship between smoking and infection in our study may be related to the fact that most of our patients were nonsmokers. A difference close to statistical significance was found between hemoglobin values (in milligrams per deciliter) for patients with and those without occurrence of infection (P = .075). Sternal wound infection can be more frequently observed in patients with low hemoglobin levels [Malone 2002]. It is not clear whether anemia or blood transfusion leads to this finding in patients undergoing cardiac surgery. This issue needs further study and examination. High serum creatinine concentrations in patients who are to undergo cardiac surgery can be a risk factor for the occurrence of sternal infection [Ku 2005]. In our study, we found no statistically significant relationship between the mean serum creatinine concentration (in milligrams per deciliter) and the occurrence of infection (P > .05).

In our study, we found a significant difference between the frequency of patients with high fasting glucose concentrations and the occurrence of infection (t = 2.562; P < .005). We determined that the incidence of SSI is 3.23 times higher in patients with diabetes than in patients without diabetes. Reports in the literature have stated that the presence of diabetes in patients undergoing cardiac surgery dramatically increases the incidence of SSI [Bhatia 2003; Harrington 2004; Ku 2005]. High blood glucose concentrations not only increase the rate of infection but also negatively influence the wound-healing process. In our study, a higher infection rate in patients with high blood glucose levels was an expected outcome.

CONCLUSION

Both noncoated and triclosan-coated suture materials are safe. Larger studies may be needed to show the benefit and cost-effectiveness, if any, of the triclosan-coated materials over noncoated materials.

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REFERENCES

Barbolt TA. 2002. Chemistry and safety of triclosan, and its use as an antimicrobial coating on Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 suture with triclosan). Surg Infect (Larchmt) 3(suppl 1):S45-53.

Bhatia JY, Pandey K, Rodrigues C, Mehta A, Joshi VR. 2003. Postoperative wound infection in patients undergoing coronary artery bypass graft surgery: a prospective study with evaluation of risk factors. Indian J Med Microbiol 21:246-51.

Escalada MG, Harwood HL, Maillard JY, Ochs D. 2005. Triclosan inhibition of fatty acid synthesis and its effect on growth of Escherichia coli and Pseudomonas aeruginosa. J Antimicrob Chemother 55:879-82.

Finkelstein R, Rabiano G, Mashich T, et al. 2005. Surgical site infection rates following cardiac surgery: the impact of a 6-year infection control program. Am J Infect Control 33:450-4.

Fleck T, Moidl R, Balcky A, et al. 2007. Triclosan-coated suture for the reduction of sternal wound infections: economic considerations. Ann Thorac Surg 84:232-6.

Ford HR, Jones P, Gaines B, Reblock K, Simpkins DL. 2005. Intraoperative handling and wound healing: controlled clinical trial comparing coated VICRYL plus antibacterial suture (coated polyglactin 910 suture with triclosan) with coated VICRYL suture (coated polyglactin 910 suture). Surg Infect (Larchmt) 6:313-21.

Gårdlund B. 2007. Postoperative surgical site infections in cardiac surgery: an overview of preventive measures. APMIS 115:989-95.

Harrington G, Russo P, Spelman D, et al. 2004. Surgical-site infection rates and risk factor analysis in coronary artery bypass graft surgery. Infect Control Hosp Epidemiol 25:472-6.

Justinger C, Moussavian MR, Schlueter C, Kopp B, Kollmar O, Schilling MK. 2009. Antibacterial [corrected] coating of abdominal closure sutures and wound infection. Surgery 145:330-4.

Ku CH, Ku SL, Yin JC, Lee AJ. 2005. Risk factors for sternal and leg surgical site infections after cardiac surgery in Taiwan. Am J Epidemiol 161:661-71.

Leonardo J, Rozzelle CJ. 2006. Antimicrobial suture use associated with a decreased incidence of cerebrospinal fluid shunt infections [abstract]. Neurosurgery 59:478. Abstract 872.

Malone DL, Genuit T, Tracy JK, Gannon C, Napolitano LM. 2002. Surgical site infections: reanalysis of risk factors. J Surg Res 103:89-95.

Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. 1999. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 20:250-78.

Marco F, Vallez R, Gonzalez P, Ortega L, de la Lama J, Lopez-Duran L. 2007. Study of the efficacy of coated Vicryl Plus antibacterial suture in an animal model of orthopedic surgery. Surg Infect (Larchmt) 8:359-65.

Mingmalairak C, Ungbhakorn P, Paocharoen V. 2009. Efficacy of antimicrobial coating suture coated polyglactin 910 with triclosan (Vicryl Plus) compared with polyglactin 910 (Vicryl) in reduced surgical site infection of appendicitis, double blind randomized control trial, preliminary safety report. J Med Assoc Thai 92:770-5.

Nichols RL. 2001. Preventing surgical site infections: a surgeon's perspective. Emerg Infect Dis 7:220-4.

Olsen M, Sundt TM, Lawton JS, et al. 2003. Risk factors for leg harvest surgical site infections after coronary artery bypass graft surgery. J Thorac Cardiovasc Surg 126:992-9.

Olsen MA, Lock-Burkley P, Hopkins D, Polish L, Sundt TM, Fraser VJ. 2002. The risk factors for deep and superficial chest surgical-site infections after coronary artery bypass graft surgery are different. J Thorac Cardiovasc Surg 124:136-45.

Rogers MA, Langa KM, Kim C, et al. 2006. Contribution of infection to increased mortality in women after cardiac surgery. Arch Intern Med 166:437-43.

Rozzelle CJ, Leonardo J, Li V. 2008. Antimicrobial suture wound closure for cerebrospinal fluid shunt surgery: a prospective, double-blinded, randomized controlled trial. J Neurosurg Pediatr 2:111-7.

Slater-Radosti SC, Van Alter G, Greenwood R, et al. 2001. Biochemical and genetic characterization of the action of triclosan on Staphylococcus aureus. J Antimicrob Chemother 48:1-6.

Storch M, Perry L, Davidson JM, Ward JJ. 2002. A 28-day study of the effect of Coated Vicryl* Plus Antibacterial Suture (coated polyglactin 910 with triclosan) on wound healing in guinea pig linear incisional skin wounds. Surg Infect (Larchmt) 3(suppl 1):S89-98.

Swenne CL, Borowiec J, Carlsson M, Lindholm C. 2006. Prediction of and risk factors for surgical wound infection in the saphenous vein harvesting leg in patients undergoing coronary artery bypass. Thorac Cardiovasc Surg 54:300-6.