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Wound Infection Following Coronary Artery Bypass Graft Surgery

Risk Factors and the Experiences of Patients

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Abstract

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The primary aim was to register the incidence of surgical wound infections (SWI) in sternotomy and leg incisions and potential risk factors for SWI following coronary artery by-pass graft (CAGB) procedures. Patients' perspectives of SWI and the subsequent treatment were also considered.

Risk factors were registered for 374 patients. Patients were contacted by telephone 30 and 60 days after surgery and interviewed according to a questionnaire about symptoms and signs of wound infections. SWI was defined according to The Centers for Disease Control. Patients with mediastinitis were also interviewed within four months about how they experienced care, how they coped and how they thought the mediastinitis would influence their future life.

SWIs were diagnosed in 30 % of the patients. Seventy-three percent of the SWIs of the leg were diagnosed within 30 days of surgery and 27% were diagnosed within 31 to 60 days. Female gender and use of a monofilament suture for skin closure were the most important risk factors for SWI of the leg. Low preoperative haemoglobin concentration was the most important risk factor for sternal SWI. Patients with mediastinitis had higher BMI and had more often received erythrocyte transfusions on postoperative day 2 or later than those without infections. Patients without a diagnosis of diabetes who had increased blood glucose concentrations during the intermediate postoperative period had an increased risk of mediastinitis. It was not possible to separate the effect of diabetes as a risk factor for SWI from that of hyperglycaemia as such. Patients' experiences were influenced by the staffs' medical knowledge, how care was given and how well information was provided. Perceived danger and stress influenced how they coped with the situation. The patients believed that the mediastinitis would not affect the final outcome of the CABG procedure, even though their confidence in this was influenced by uncertainties about the rehabilitation process.

Keywords: coronary artery bypass graft, surgical wound infection, infection control, risk factor, blood glucose, postoperative, Saphenous vein harvesting, wound evaluation scale, mediastinitis, psychology, quality of life

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To Louisa, Johanna
and Ingemar

”Respekt för individen”
Text på baksidan av ULS sjuksköterskebrosch

List of papers included in the thesis

This thesis is based on the following papers, which are referred to in the text by their Roman numerals:

I Swenne CL, Lindholm C, Borowiec J, Carlsson M. Surgical-site infections within 60 days of coronary artery by-pass graft surgery. Journal of Hospital infection 2004; 57: 14-24

II Swenne CL, Lindholm C, Borowiec J, Schnell AE, Carlsson M. Perioperative glucose control and development of surgical wound infections in patients undergoing coronary artery by-pass graft. Journal of Hospital Infection 2005; 61: 201-212

III Swenne CL, Borowiec J, Carlsson M, Lindholm C. Prediction of and risk factors for surgical wound infection in the Saphenous vein harvesting leg in patients undergoing coronary artery by-pass. Thoracic and Cardiovascular Surgoen 2006; 54: 300-306

IV Swenne CL, Skytt B, Lindholm C, Carlsson M. Patients' experiences of mediastinitis after coronary artery by-pass graft procedure. Submitted

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The studies were approved by the Ethics Committee of the Faculty of Medcine of Uppsala University.

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Abbreviations

BIMA	Bilateral Internal Mammary Artery
BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CDC	Centers for Disease Control
CFU	Colony Forming Units
CI	Confidence interval
CIII	Continuous Intravenous Insulin Infusion
CoNS	Coagulase-Negative Staphylococci
CPB	Cardiopulmonary Bypass
CRP	C-reactive protein
EVH	Endoscopic Vein Harvest
ICU	Intensive Care Unit
IGF1	Insulin-like Growth Factor 1
IMA	Internal Mammary Artery
OGTT	Oral Glucose Tolerance Test
OHA	Oral Hypoglycaemic Agent
OR	Odds ratio
OVH	Open Vein Harvest
SSI	Surgical Site Infection
SWI	Surgical Wound Infection

Introduction

> "I've talked to alot of people who have had this kind of surgery. Most of them say that it was really wonderful. Back on your feet after a week. Then the pain and everything is gone. Some thought it was difficult. I thought they were whiners. I thought…I'm not like that. I can take the pain, and I did. There were so many other experiences. I was shocked by the way things turned out . Instead of being a walk through the hospital and back home it became a traumatic experience."
>
> Quote from man aged 60

Postoperative wound infections are serious health care problems, causing suffering and increased costs. In her time, Florence Nightingale found the same problem and wrote in her book *Notes on hospitals* "It may seem a strange principle to enunciate as the very first requirement in a hospital is that it should do the patient no harm" [1].

Five thousand ninety persons underwent coronary artery bypass graft (CABG) surgery in Sweden 2004 [2]. Seventy-eight percent were males, 60% were ≥65 years old, 43% were ≥70 years old and 7% were ≥80 years old. Surgical wound infections (SWIs) of the leg and/or sternal wound have been reported to occur in 2%-20% of the patients following a coronary artery bypass graft operation (CABG) [3]. Using a broad definition of SWI, Tegnell et al [4] reported an incidence as high as 30%. Deep sternal infections, e.g. mediastinitis, have been reported to occur in 0.5% to 5% of CABG procedures [2]. A Swedish study showed that a postoperative mediastinitis increases hospital costs for a CABG procedure from $15,000 to $30,000 [4]. In the U.S., mediastinitis following thoracic surgery increased costs by $41,559 per patient [6]. In Australia, superficial sternum infection and a superficial or deep wound infections in the Saphenous vein harvest site on the leg increased costs for postoperative hospitalisation and antibiotic treatment by $12, 419 per patient, and mediastinitis increased costs by $31,597 per patient [7]. Much would be gained in both relief of suffering and control of costs if SWIs were kept to a minimum.

The occurrence of SWI after a CABG procedure is common and causes costs for both healthcare consumption and suffering. A lot could be gained if SWI could be prevented. The etiology and development of SWI is multifactorial. A broad investigation into risk factors for SWI would be necessary in order to form the basis for intervention.

Definition of surgical wound infections

Different definitions of SWI are used in different studies. The Centers for Disease Control (CDC) definition of SWI is the most commonly used in the United States [8] but is not always applied in Europe [9, 10].

In the CDC definition [8] a *superficial incisional surgical site infection* must occur within 30 days of procedure and involves only the skin or subcutaneous tissue around the incision. The infection is diagnosed by purulent drainage from the incision *or* organisms isolated from an aseptically obtained culture of fluid or tissue from the incision *or* at least one of the signs/symptoms of infection (pain, tenderness, localised swelling, redness, heat) and that the incision is deliberately opened by a surgeon, unless the culture is negative. Stitch abscesses are not considered a superficial SWI. A *deep incisional surgical site infection* must occur within 30 days of procedure and involves deep soft tissues, such as the fascia and muscles. The infection is diagnosed by purulent drainage from the deep incision *or* a deep incison spontaneously dehisces or is deliberately opened by a surgeon and the patient as signs of inflammation unless cultures are negative *or* the finding of an abscess or other signs of infection on direct examination. An *organ/space surgical site infection* must occur within 30 days of procedure and involves any organ or space other than the incision. The infection is diagnosed by purulent drainage from a drain in the organ/space *or* positive bacterial cultures from the organ/space *or* the finding of an abscess or other signs of infection on direct examination. By this definition mediastinitis is an organ/space SWI [8]. It is, however, evident that there are alternative definitions and considerable room for interpretations of the CDC criteria.

A study in the Netherlands compared a local complication surveillance definition of SWI with the criteria of CDC [10]. The local program did not include post-discharge surveillance up to 30 days and the reported incidence of SWI was 50% lower than the incidence generated by CDC criteria. It is therefore important to have a defined time limit in the criteria used.

In a review of the literature for this thesis the definition of SWI, duration of follow-up and incidence of SWI were scrutinised. The definitions of SWI used in thirty-three studies of CABG from 1990 to 2006 [5, 11-42] were analysed. Sixteen studies were retrospective, fifteen were prospective and two were both retrospective and prospective. Twenty-four of the studies had a CDC definition or a modified CDC definition including descriptions of the signs used to diagnose SWI and information as to whether bacterial cultures had been performed (Table 1). However, as many as eight studies had no definition of SWI. One study used local signs in the wound area according to the ASEPSIS wound scoring system as a definition of SWI [5].

Table 1. Definition of surgical wound infection among patients operated with coronary artery bypass graft procedure in the review of 33 articles

Total number of studies	33
CDC	12
Modified CDC/description of signs	6
Modified CDC/description of signs; confirmed by bacterial culture	6
"Wound complication"	6
No definition	2
Modified ASEPSIS score	1

Duration and method of follow-up

Diagnosing SWI following discharge from hospital meets with difficulties and different surveillance protocols have been used with varying degrees of success. Examples are direct examination of surgical wounds at follow-up visits to surgery clinics or physicians' offices [43], or retrospective reviews of medical records [44]. Other methods are patient surveys by mail or telephone [45, 46] direct examination conducted elsewhere in the health care system and reported back to the infection control office of the operating hospital [5, 47, 48]. Multicentre collaborative surveillance projects have become a common method of infection control surveillance to aggregate and compare interhospital SWI rates. Each institution uses standardised definitions of SWI, risk adjustment and reporting methodology [41, 49]. The aim is to establish risk-adjusted, procedure-specific SWI rates for identifying indicators and to establish risk factors for specific operative procedures. It is, however, conceivable that the choice of procedure influences the degree of ascertainment.

Following general surgery, trauma surgery, thoracic surgery and transplantation surgery almost 90 % of SWIs are diagnosed within 21 days and 96% within 30 days of surgery [43]. When isolated CABG procedures was followed the SWI occurred within 21.5 (range 4-315) days [36]. Twenty-five percent of the SWI were then identified during the hospital stay, 59% during readmission or 16% by postdischarge surveillance [36]. This observation indicates that follow-up beyond discharge, which often are only days after surgery, is necessary to detect all SWI.

In the review of duration of follow-up in thirty-three studies of CABG from 1990 to 2006 [5, 11-42] two studies had a follow-up limited to the hospital stay, ten studies had a postoperative follow-up for up to 30 days and eight studies had a minimum postoperative follow-up for more than 30 days. However, thirteen studies did not define the duration of postoperative follow up (Table 2).

Table 2. Duration of follow up for surgical wound infection among patients operated with coronary artery bypass graft procedure in the review of 33 articles

Total number of studies	33
During hospital stay	2
Follow up to 30 days	10
Minimum follow up > 30 days	8
Not stated	13

Incidence of surgical wound infections

In the review of thirty-three studies of CABG from 1990 to 2006 [5, 11-42] the reported incidence of SWI varied. Mediastinitis was reported in 0.2%-7% of the patients, superficial SWI of the chest in 2.1%-8.4% and SWI of the leg/limb in 2.1%-15%. In most studies SWI were not categorised into deep or superficial SWI (Table 3).

Table 3. Incidence of surgical wound infection among patients operated with coronary artery bypass graft procedure in the review of 33 articles

	Number of studies	Range (%)
Mediastinitis	29	0.2-7
Superficial SWI chest	17	1.2-8.4
Leg/limb	7	2.1-15

Risk factors for SWI

Many studies of SWI following CABG have attempted to identify specific risk factors for infection. Some risk factors emerge from several studies and are well documented. Risk factors for SWI may be patient-related or my relate to the pre-, intra- and postoperative surgical treatment and care of the patient.

Patient-related risk factors demonstrated in multivariate analyses in the literature review from 1990 to 2006 are advanced age [12, 16, 17, 22], male gender [11, 16, 27], female gender [12, 14, 15, 17, 27, 31, 42], high Body Mass Index (BMI)/obesity [15, 28, 29, 33, 34, 39-42], diabetes [11, 12, 16, 17, 19, 23, 26, 28, 29, 30, 33, 37, 41], chronic obstructive pulmonary disease [14, 17], current smoking [18], peripheral vascular disease [12, 14, 31], nasal carriage of *Staphylococcus aureus* [28], connective tissue disease [27], preoperative hemodynamic instability [37], previous cardiovascular intervention [29, 39], renal failure [11, 14, 37], New York Heart Association functional class ≥3 [34, 39], heart failure [11] and preoperative steroid medication [23]. There was an interaction between pairs of risk factors such as obesity and diabetes [33, 35], diabetes and advanced age [33] and obese and urgent CABG procedure [35].

There were no preoperative risk factors identified in the review by multivariate analysis.

Intraoperative risk factors reported in various studies are antimicrobial prophylaxis ≥2 hours before incision [30], emergency surgery [11, 14, 22], use of Internal Mammary Artery (IMA) [19, 26], use of Bilateral IMA [11, 16, 17, 26, 37, 42] duration of aortic cross clamp [26], duration of cardiopulmonary by-pass time (CPB) [12, 14, 22, 39], prolonged surgery [13], number of erythrocyte concentrate transfusions [42], number of Saphenous vein grafts [34], length of wound incision [18], staple use for skin closure [30] and use of Ace elastic bandage in the operating theatre [13].

Postoperative risk factors reported in various studies are reoperation on sternum [19, 34], respiratory failure [27], use of intraaortic balloon pump [31], postoperative renal failure [17], number of erythrocyte concentrate transfusions [42], use of inotropic agents at intensive care unit (ICU) [13], use of beta adrenergic drugs for respiratory problems [40], elevated C-reactive protein (CRP) after postoperative day 3 [5], sepsis and/or endocarditis [37], prolonged ICU stay [27] and length of hospitalisation [19, 37].

Examples of risk factors demonstrated by univariate analysis only are hair removal with razor [25], intraoperative risk factors such as hygiene in the operating room [50, 51] and presence of glove punctures [52].

The six most common risk factors for SWI in the review from 1990-2006 are presented in table 4. Diabetes has been identified as a risk a factor in 39% of the studies and obesity in 27%. It is notable that although many of these risk factors are recognised as well-known and well-documented, they are not consistently demonstrated in all studies.

Table 4. The six most common risk factors for surgical wound infection among patients operated with coronary artery bypass graft procedure in the review of 33 articles

Risk factors	Number of Studies
Diabetes	13
Gender female/male	6/3
BMI/obesity	9
Bilateral IMA	7
Age	4
Duration of cardiopulmonary by-pass time	4

Saphenous vein harvesting with continuos open incision as a risk factor for SWI

It is important to correctly and effectively diagnose SWI in the graft harvest site after open vein harvest (OHV) to achieve a correct identification of risk factors for SWI. Only five studies in the review from 1990 to 2006 specifi-

cally studied SWI of the leg after Saphenous vein harvesting with continuos open incision in the analysis [12, 13, 15, 18, 31]. From 1990 and onwards endoscopic vein harvesting become increasingly common [53].

Demonstrated patient-related risk factors for SWI of the leg using multivariate analyses in the review are female gender [12, 31], age [12, 15], BMI [15], diabetes [12] and peripheral vascular disease [12, 31].

Intraoperative risk factors include duration of cardiopulmonary by-pass time [12], length of wound incisions [18], use of Ace elastic bandage in the operating theatre [13] and prolonged surgery on the leg [13]. Surgical considerations, which may be important for wound healing such as the presence of sutures, foreign bodies, suturing quality and mechanical stress on the wound have not been studied as risk factors SWI (Figure 1).

Postoperative risk factors comprise use of postoperative intraaortic balloon-pump [31] and administration of inotropic agents intravenously in the ICU [13]. Anaesthetic considerations that may be important for wound healing, such as peripheral tissue perfusion, perioperative body temperature and concentration of inspired oxygen have not been studied as risk factors for SWI (Figure 1).

The three most common risk factors for SWI of the leg in the review from 1990-2006 are presented in table 4. The definition of SWI in these studies were modified CDC/descriptions of signs [15, 18] or only "wound complication" [12, 13, 31]. None of the risk factors on the leg are consistently demonstrated in all studies.

Table 5. The three most common risk factors for surgical wound infection in the Saphenous vein harvesting site among patients undergoing coronary artery bypass graft procedure in the review of 33 articles

Risk factors	Number of Studies
Age	2
Gender female/male	2/0
Peripheral vascular disease	2

In a study when open OVH was compared to endoscopic vein harvest (EVH) the EVH did not prolong the duration of the operation if two or more Saphenous vein grafts were needed. Postoperative pain was less in the EVH group [54] and EVH also reduced leg wound complications [54, 55]. Another study comparing OHV and EVH showed that the overall complication rate depended on site of harvesting, vein-related variables and patient characteristics rather than the method of vein harvesting [55].

Diabetes as a risk factor for SWI

Diabetes is a well-documented risk factor for SWI following CABG [11, 12, 16, 17, 19, 23, 26, 28, 29, 30, 33, 37, 41]. The observation that tight blood glucose control

lowers morbidity and mortality in general intensive care patients, irrespective of whether they have a diagnosis of diabetes or not, is of interest [56]. High perioperative blood glucose concentrations have indeed been identified as a risk factor for SWI following thoracic surgery [30, 57-60]. An association between postoperative infectious complication and blood glucose concentration > 200 mg/dL (11.1 mmol/l) 36 hours after a CABG procedure has been demonstrated [59]. Postoperative hyperglycemia in patients with diabetes has also been associated with adverse outcomes such as death, myocardial infarction, stroke and septic complications before hospital discharge [60].

Independent effects of diabetes and hyperglycaemia on the incidence of SWI in cardio-thoracic surgery have been hard to separate. A study by Trick et al [30] diabetes was not an independent risk factor when blood glucose concentrations were held below 200 mg/dL, but the incidence of SWI increased when blood glucose concentrations were above this limit. In a group of patients with diabetes, the implementation of a protocol aiming at better postoperative blood glucose control resulted in a decreased incidence of SWI suggesting an effect of blood glucose *per se* [58]. Furnary et al [61] has introduced the Portland protocol. The aim of which is a blood glucose concentration of 100-150 mg/dL (5.5-8.3 mmol/l) during surgery, intensive care and in the surgical ward. They showed that hyperglycemia in patients with diabetes, not the diagnosis of diabetes *per se* was associated with SWI. Latham et al [57] showed that postoperative hyperglycemia and previously undiagnosed diabetes was independently associated with development of SWI. Preoperative HbA_{1c} can not predict postoperative SWI or other postoperative complications in patients with or without diabetes [57, 62], suggesting that the perioperative blood glucose concentration is an important risk factor.

An elevated preoperative fasting blood glucose concentration, 126 mg/dL (6.9 mmol/l) or higher, is an independent predictor of postoperative mediastinitis irrespective of whether the patient has a preoperative diagnosis of diabetes or not [63]. A large number of patients with coronary artery disease indeed have abnormal glucose metabolism [64, 65]. Bartnik et al [65] emphasises the importance of oral glucose tolerance tests (OGTT) in patients with coronary artery disease. In their study, two thirds of the patients with abnormal glucose regulation would have remained undiagnosed if an OGTT had not been performed. According to the Provisional Report of a WHO consultation [66] a fasting venous plasma glucose concentration of less then 110 mg/dL (6.1 mmol/l) has been elected as normal. The Expert Committee on the Diagnosis and Classification [67] has recommended screening of individuals aged ≥45 years and of younger individuals at high risk for developing diabetes. In this respect patients with coronary artery disease should be considered high-risk patients. It would be of importance to diagnose diabetes preoperatively in order to improve care and outcome of the CABG procedure.

Other factors affecting surgical wound healing

There are other factors such as surgical and anaesthetic considerations, which may affect wound healing (Figure 1). Many of the risk factors registered in the reviewed articles [5, 11-42] are risk factors that are easy to find in medical records. However, some surgical factors, for example presence of suture or foreign body, suturing quality and heamatoma has not been considered in the analysis. Nor has anaesthetic factors such as tissue perfusion, perioperative body temperature, concentration of inspired oxygen and pain been considered in the analysis. These may be important for successful wound healing [68] and should be considered in the analysis for potential risk factors for SWI following CABG procedure. It is notable that some would require a prospective registration.

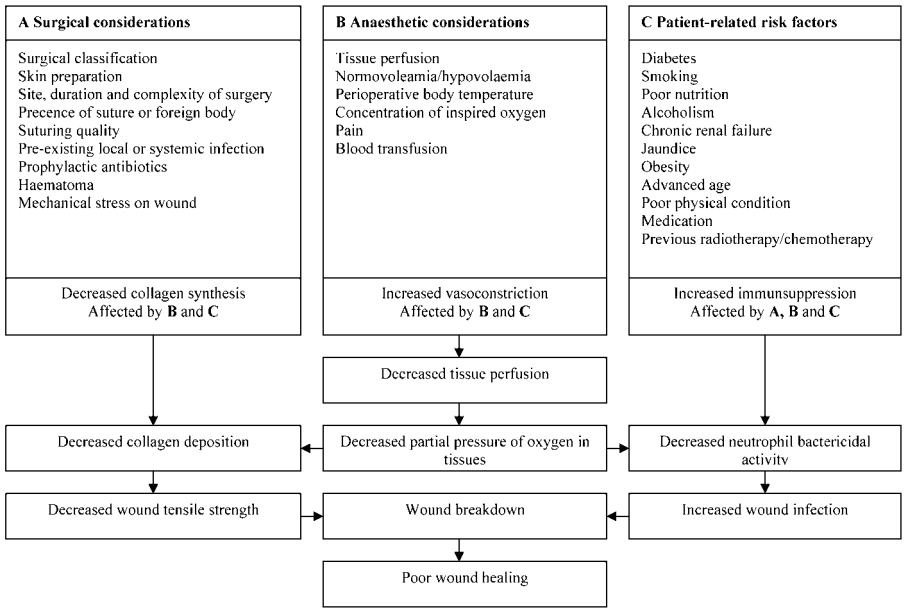

Figure1. Risk factors affecting surgical wound healing, adapted from Buggy D. [68]

Wound evaluation scales

The wound evaluation scale ASEPSIS was developed to predict SWI after CABG procedures [69] and has been used in modified versions in several studies [5, 70, 71]. The different wound characteristic measured are A – additional treatment such as antibiotics, S – separation of deep tissue, E – erythema exceeding 5 mm, P – purulent exudate, S – serous exudate, I – isolation of bacteria and S – hospital stay >14 days. The scoring of the different characteristics is carefully defined and dependent on the extension of the signs. The ASEPSIS wound scoring system can predict SWI [5]. It has been developed for clinical trails evaluating antibiotic prophylaxis. It is time consuming to administer and its use limited when patients are discharged early from hospital [70, 71]. Haematoma (bruise formation) is not considered in the scale. One study showed that at discharge from the hospital signs such as erythema, exudate or the combination of erytema and exudate were associated with impaired wound healing of the leg harvest site following CABG [72]. The Southampton wound assessment scale [73, 74] is a further development of the ASEPSIS system and used in the community surveillance of complications. It is less extensive, but the extension of the different signs still defined, and it is easier to administer in routine clinical practice. It has, however, not been used to predict SWI after CABG procedures.

The DISINFECT wound assessment scale [75] was developed to assess leg wounds following Saphenous vein harvesting. The DISINFECT scale defines stages of normal wound healing, severity of wound infection and appropriate use of antibiotics. Haematoma is considered in this assessment scale. It has been tested on 100 patients undergoing CABG requiring Saphenous vein. The DISINFECT wound scoring system can then predict SWI [75].

Wound microbiology in SWI after CABG procedure

The level of bacterial burden is thought the most significant risk factor for SWI. In a classification of operative wounds based on the degree of microbial contamination [76] a CABG procedure is classified as “clean surgery” in that it is elective, without an acute inflammatory response, without intraoperative sources of bacteria and without violation of aseptic technique [76]. Following such operations SWI should be expected to be rare. Wound contaminations may nevertheless originate from three sources. Firstly, in the environment of the operating theatre and wards, airborne micro-organisms such as S*taphylococcus aureus* and Coagulasenegative staphylococci may be found. Secondly, the normal skin microflora of staff and patients is continuously released into the air and may contaminate the wound for example with *Staphylococcus epidermidis*. Thirdly, endogenous sources such as mucous

membranes of the gastrointestinal, oropharyngeal and genitourinary areas contain *Enterococcus*, *Escherichia coli* and *Pseudomonas aeruginosa* that may spread from the hands of staff and patients into the surgical wound. Bacteria from these three sources are the most commonly reported in reviews of SWI following CABG procedures [5, 11-42].

However, actions can be taken to prevent airborne transmission by operating theatre ventilation to achieve ultra clean air with <10 Colony Forming Units (CFU)/m^3 in the operating room [50]. The staff can wear tightly woven scrub suits, which prevent bacteria from the skin flora being released into the air [51]. Good routines and compliance with hand antisepsis with an alcoholic compound [77] is also of great importance for preventing transmission of bacteria. Despite such measures a significant incidence of SWI persists following "clean surgery" CABG operations.

Patients' perspectives and experiences

Many studies have investigated the incidence of and risk factors for mediastinitis following a CABG procedure [5, 11-42] but few have focused on the patients' personal experiences of a SWI [78, 79]. The unexpected occurrence of mediastinitis is a severe and potentially life-threatening complication. A deeper understanding of the patients' experiences could change the focus of the care providers from the curative outcome to include more aspects of emotional and psychological well-being. These aspects are easily disregarded if the outcome of care is evaluated only from the medical and curative aspects of the CABG and mediastinitis. It would therefore be important to assess the patients' experiences and ability to cope as part of an outcome measure.

The ability to cope is individual. Individual knowledge influences the ability to evaluate the stressor together with psychological, social and cultural resources [80]. Well-being in its widest sense depends on how a person can cope during illness, stress and other threats in everyday life [80]. There are two possible strategies to handle stress and threats. Problem-focussed coping refers to problem-management by active problem solving and information seeking. An emotion-focussed coping strategy involves attempts to change the way one thinks or feels about stressful situations. Problem-focussed coping strategies will be most effective for stressors that can be changed whereas emotion-focussed strategies are most useful when the stressors are unchangeable [80]. Emotion-focused strategies of coping can impair recovery by adapting to and retaining illness-related behaviour. A person can deny or avoid a stressful situation, which can restrain them from emotional distress [78]. The denial or avoidance can in turn restrain them from taking suitable actions that could make them feel better in the long-term perspective after recovery of the mediastinitis.

The issue approached in this thesis is to study a more correct incidence of SWI and more correct identification of different risk factors for mediastinitis, superficial SWI on sternum and SWI on the Saphenous vein harvesting leg. Another issue approached is to examine weather a postoperative clinical wound assessment could predict SWI and patients experiences of a postoperative mediastinitis following a CABG procedure.

Aim

The general aim of the present thesis was to register the incidence of SWI after CAGB procedures. Both the sternotomy and the leg incision following vein harvesting were considered. Potential risk factors for SWI at the respective sites were studied. Also, patients' perspectives of a surgical wound infection, and its ensuing treatment was to be studied.

Specific aims for the separate studies:

- To register the incidence of SWI after vein graft harvesting on the leg and after sternotomy within 60 days of a CABG procedure, using a precise definition of SWI and attempting to reach a high degree of ascertainment. A second aim was to investigate potential risk factors for the development of SWI and related to the patient and the preoperative, intraoperative and postoperative surgical treatment and care.

- To examine the significance of postoperative blood glucose control as a risk factor for SWI after vein graft harvesting on the leg and sternotomy within 60 days of a CABG procedure in patients with and without diabetes.

- To examine different potential surgical risk factors for wound infection when the Saphenous vein was harvested for a CABG procedure and to investigate the effectiveness of an occlusive glycerinated hydrogel dressing for reducing postoperative SWIs. A further aim was to examine whether a postoperative clinical wound assessment could predict SWI.

- To capture patients' experiences of the medical and nursing care they received for post-CABG mediastinitis. How they coped with the stress and threats posed by the mediastinitis and its treatment and how they thought it would influence their future life were evaluated.

Method

Design

Studies I, II and III were a prospective post discharge evaluations of surgical wound infections at 30 and 60 days after surgery. The design was descriptive and predictive. Study IV comprised interviews with patients within four months of discharge from hospital after treatment for mediastinitis. The design was explorative in order to look for new insights and new understanding of patients' experiences of mediastinitis.

Paticipants

Study I, II

Patients planned to undergo CABG procedures at the Department of Cardiothoracic Surgery at the University Hospital of Uppsala were considered for inclusion. Inclusion criteria were either diabetes treated with oral hypoglycaemic agents (OHA) or insulin or the absence of a preoperative diagnosis of diabetes. Exclusion criteria were malignant disease, steroid or immune suppressive medication, and inability to speak Swedish. Patients were recruited from September –98 to June –02 during the academic periods, two days a week. Patients were identified on the daily operating schedule. An attempt was made to recruit all patients with diabetes and a random sample drawn by lottery of patients without diabetes. In total 437 were eligible for inclusion. Twenty-seven (8 with diabetes, 19 without diabetes) were excluded because of steroid- or immune suppressive medication or language difficulties. In all, 410 patients were approached and 396 (97%) agreed to participate. In total, 192 patients with diabetes and 204 patients without diabetes were included. When records were reviewed postoperatively, five patients in the non-diabetic group were found to have diabetes treated with diet only. These patients were transferred to the diabetic group. Study I and II included 197 patients with diabetes and 199 without diabetes. Twenty-two patients did not complete the study, leaving 184 patients with diabetes and 190 patients without diabetes for surveillance of surgical site infections (Figure 2).

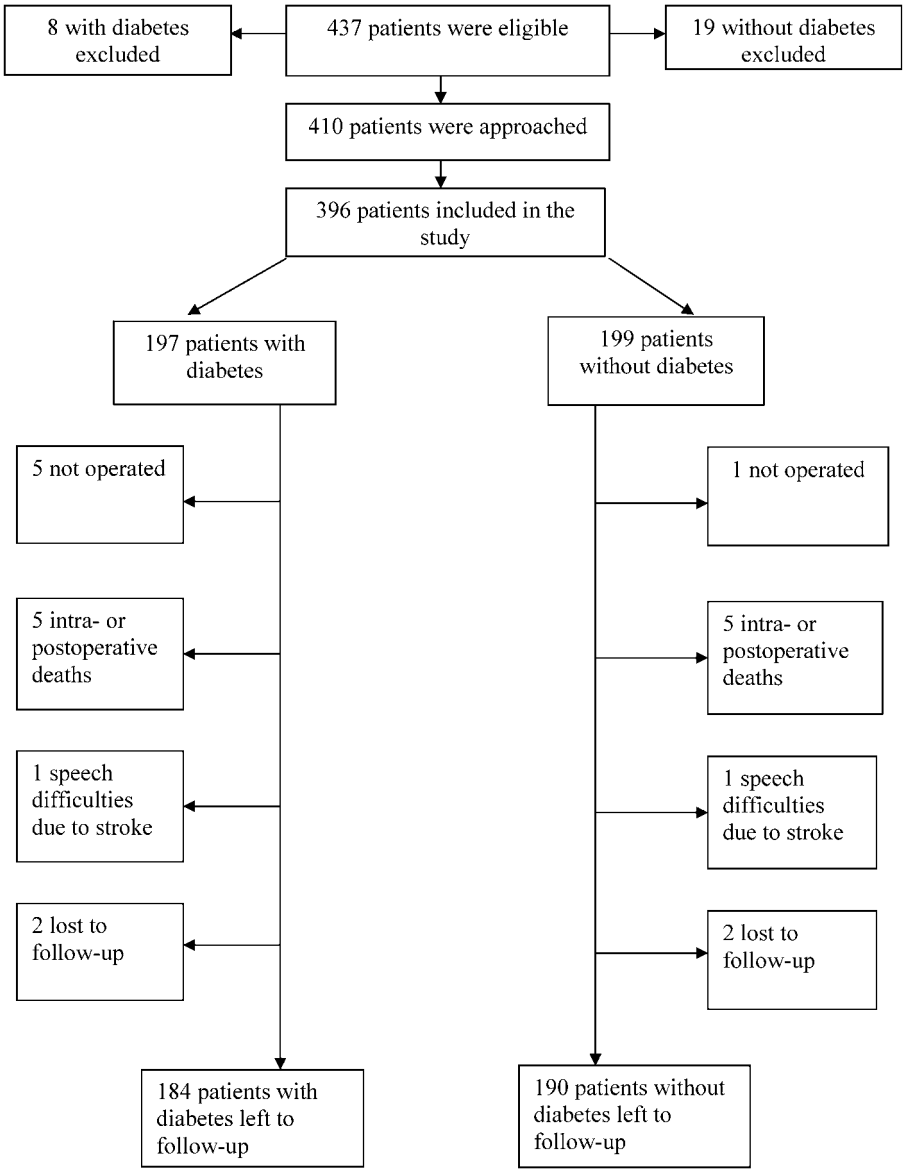

Figure 2. Included and lost patients in studies I and II

Study III

Study III is part of the protocol for studies I and II (Figure 2). Seventeen patients did not undergo Saphenous vein harvest for grafts; of these seven had diabetes and ten did not. In four patients with and four patients without diabe-

tes radial artery grafts were used. Three patients with and six patients without diabetes had only mammary artery grafts. One patient without diabetes was lost to follow-up for surveillance for leg infections. This left 356 patients, 177 patients with and 179 patients without diabetes for surveillance of leg infections (Figure 3).

Study IV

Patients with mediastinitis following a CABG procedure were identified in the hospital's in-patient records. Eighteen patients with mediastinitis diagnosed during October 2003, March 2004, December 2004-April 2005 and July-December 2005 was identified. The patients were informed about the study by mail and were telephoned one week later to ascertain whether they were willing to participate. The author telephoned the patients and carried out all the interviews. Thirteen of the patients, six men and seven women, agreed to participate. Treatment had been successful for all thirteen patients, in that the mediastinitis had healed. The participants were 64 ± 5.6 (mean ± SD, range 56-74) years old. Three men and two women declined participation. They were 73 ± 3.0 (range 69-77) years old. Two of the patients who declined participation said that their experiences were so unpleasant that they did not want to talk about them, one patient was still feeling so weak that she felt she could not participate and two patients did not give any particular reason for not participating.

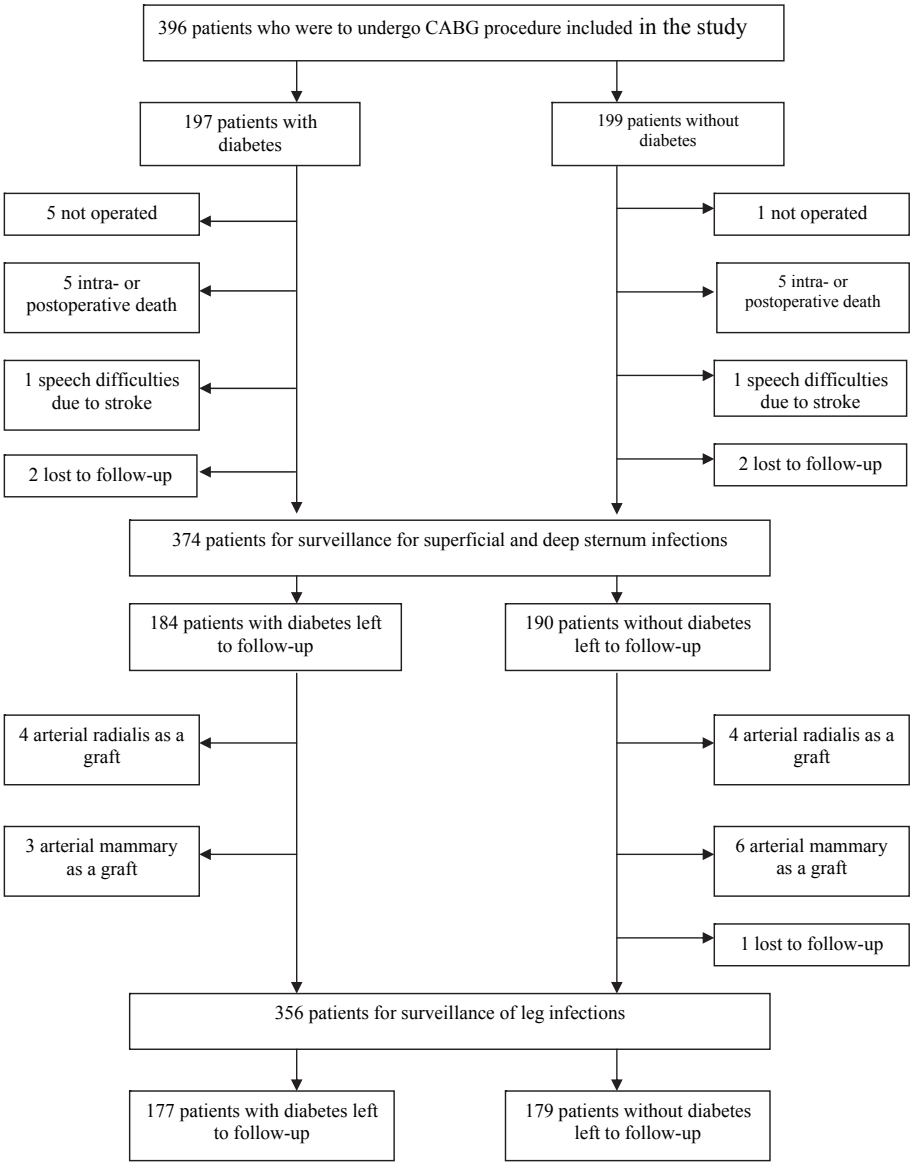

Figure 3. Included and lost patients in study III

Data collection

Protocol for data collection, Study I, II, III

Previously demonstrated and potential patient related, preoperative-, intraoperative-, vein harvesting-, suture technique- and postoperative risk factors were registered prospectively in a protocol, table 6.

All surgical incisions on the sternum and the vein harvest leg were evaluated by nurses and nursing aids on postoperative day four. The presence or absence of wound gap, bleeding, haematoma, oedema, serous discharge, erythema and pus was recorded. The number of postoperative days in hospital were registered the day the patient left the hospital.

Table 6. Risk factors for SWI in Study I, II and III

Risk factors	Study I	Study II	Study III
Patient related	Age	Duration of diabetes (years)	Circumference of calf
		Diabetes treatment	Circumference of thigh 10 cm above patella
	Gender M/F	Proportion of patients reporting long term complications of:	
	weight	- Eye	
	height	- Kidney	
	Body Mass Index	- Peripheral nerves	
	Current smoking	Preoperative HbA1c	
	Diabetes		
	Preoperative insulin-like growth factor 1		
	Preoperative haemoglobin concentrations		
	Preoperative serum creatinine concentrations		
Pre-operative	Preoperative days in hospital		
Intra-operative	Number of Saphenous vein grafts		
	Number of legs operated 0/1/2		
	Internal mammary artery (IMA) 0/1/2		
	Duration of operation		
	Duration of leg operation		
	Duration of cardiopulmonary by-pass time (CPB)		
	Duration of aortic cross clamp time		
	Number of persons in theatre		
	Number of scrubbed persons		
	Number of glove changes		
	Number of door openings in theatre		
	Intact sterile draping		
	Non-operated leg covered		
Vein harvesting			Distance between surgical incision and medial malleolus
			Use of drain
			Use of clip at medial malleolus

Suture technique			Separate sutures for keeping the tissue flap together Running subcutaneous absorbable braided polyglacitin 3-0 (Vicryl®) Running subcutaneous absorbable braided polyglacitin 2-0 (Vicryl®) Running subcutaneous monofilament glycomer 4-0 (Biosyn®) Running intracutaneous absorbable braided polyglacitin 3-0 (Vicryl®) Running intracutaneous monofilament glycomer 4-0 (Biosyn®) Interrupted skin monofilament nylon 3-0 (Ethilon®) Interrupted skin monofilament nylon 2-0 (Ethilon®) Skin staples
Post-operative	Reoperation on sternum Reoperation on the leg Postoperative bleeding Number of days in intensive care unit Haemoglobin concentrations day 1 Haemoglobin concentrations day 2 Haemoglobin concentrations day 3 Erythrocyte transfusions day 0 Erythrocyte transfusions 1 Erythrocyte transfusions day 2 or later Number of postoperative days in hospital	Mean blood glucose day 0 Mean blood glucose day 1 Mean blood glucose day 2	

Questionnaire for SWI evaluation, Study I, II, III

The questionnaire for SWI evaluation was a structured infection surveillance questionnaire concerning symptoms and signs of SWI [8]. It included questions about occurrence of discharge, purulent discharge, redness, local rise in temperature, pain or oedema in the incision of the wounds. The questionnaire also included questions about antibiotics for any kind of postoperative infection. The definition of SWI was the patient's report of purulent discharge from the wound. They were also considered to have a SWI if there was serous discharge, inflammatory signs and a positive bacterial culture. Prior to the present data collection the questionnaire had been tested on 40 patients and found applicable for the surveillance of SWI in cardiothoracic patients [81].

Protocol for glucose evaluation, Study II

The review of postoperative blood glucose control in patient records included registration of whether the patient had 10% glucose infusions during the operation, day zero, one and two. It also included notes of whether the patient had continuous intravenous insulin infusions (CIII), intermittent insulin injections or no insulin treatment on day zero, one and two. The mean of all blood glucose measurements of each postoperative day was calculated.

Wound evaluation scale, Study III

The scale for wound evaluation was constructed at the Department of Cardiothoracic Surgery and has been in clinical use for several years. It has however, not been tested for validity and reliability.

Interview manual, Study IV

An interview manual with semi-structured, open-ended questions covered three areas:

1. *How the patient experienced the medical and nursing care of the mediastinitis.* The period between the CABG procedure and the diagnosis of mediastinitis, the readmission to the hospital, the notification of the diagnosis, the hospital stay, the discharge and the period immediately after in-patient treatment of the medisatinitis were covered.

2. *How the patient coped to manage the mediastinitis*, *its treatment and care*. The period between the CABG procedure and the diagnosis of mediastinitis, the readmission to the hospital, the notification of the diagnosis, the hospital stay, the discharge and the period immediately after in-patient treatment of the medisatinitis were covered.
3. *How the patient thought the mediastinitis would influence his/her future life.* Both the immediate future and the long time perspective were considered.

Procedure

Evaluation of risk factors and SWI, Study I, II, III

Previously demonstrated and potential patient-related, pre-, intra- and postoperative risk factors were registered for all patients. For calculations, the day of operation was denoted day zero and day one started at six a.m. the morning following surgery. The author recruited the patients, gave instructions to the patients for the telephone interviews and interviewed the patients 30 and 60 days after the operation. The patient-related and preoperative risk factors were registered by the auther. The nurses and nursing aids in the operating room registered the intraoperative risk factors. The nurses, nursing aids and the author registered potential postoperative risk factors in the ICU and in the ward. The definition of SWI used in these studies was a modified CDC definition [8]. 1) Purulent drainage or 2) serous discharge, isolation of an organism from the incision site and at least one of the clinical findings pain, oedema, erythema or local rise in temperature. The patients received a structured infection surveillance questionnaire concerning symptoms and signs of SWI before discharge from the hospital. They were asked to make notes if any complication occurred. Patients reporting discharge from the wound they were asked during the telephone interviews whether a bacterial culture had been performed. If this was the case, the culture was confirmed with the microbiological laboratory. The patients were also asked whether they had been treated with antibiotics for any kind of postoperative infection. They were considered to have a SWI if they reported purulent discharge from the wound. They were also considered to have a SWI if they had serous discharge, inflammatory signs and a positive bacterial culture had been obtained. The isolation of any microorganism was then considered a positive culture. After completion of the telephone interviews it was possible to review patient records for missing data. The staff was informed by the author about the study before it was started.

Blood glucose evaluation, Study II

Duration of diabetes and presence of long-term complications was assessed by self-report. The patients were asked when diabetes was diagnosed and if they had diabetic long-term complications of the eyes, kidneys or peripherals nerves. A preoperative HbA_{1c} measurement was obtained in all patients with diabetes. All patient records were reviewed retrospectively for 10% glucose infusions during the operation, blood glucose concentrations and insulin therapy day zero, one and two. Postoperative glycaemic control was defined as the means of all blood glucose measurements postoperative day zero, one and two.

Surgical technique evaluation, Study III

The largest circumference of the upper calf and the lower thigh ten centimetres above the upper margin of the patella was measured with a measuring-tape. The duration of the operation on the leg, whether the skin of the unoperated leg was covered with a disposable incision towel, the location of surgical-site incisions, the type of ligatures, clips and sutures used was noted for all patients. All surgical-site incisions were randomly assigned to a conventional absorbent dressing or to a hydrogel dressing (Elasto-Gel®) consisting of 65% glycerin, 17.5% water and 17.5% polymeric matrix of acrylamide. All operated legs were wrapped with an elastic compressive bandage for the first 24 hours postoperatively. A nurse or a nursing aid evaluated all surgical-site incisions on the leg on postoperative day four for 1) splitting, 2) bleeding, 3) heamatoma, 4) oedema, 5) serous discharge, 6) local rise in temperature, 7) pain, 8) redness and 9) pus visible to the eye. The wounds were photographed and all photos of leg surgical-site incisions were evaluated for 1) splitting, 2) heamatoma, 3) oedema, 4) redness and 5) pus visible to the eye by a nurse not involved in the data collection and blinded to the identity of the patients.

Interview, Study IV

The participants were interviewed within four months after discharge from hospital. The interview was conducted at a place convenient to the patient. It was considered important that the patient were interviewed alone. However, in the two first interviews the wives of the participants were present. The interviews lasted for 20-90 minutes and were tape-recorded. An interview manual with semi-structured, open-ended questions was used.

Setting

Hygiene procedures, Study I, II, III

Patients were usually admitted to the hospital the day before surgery. Preoperative preparation of the skin of the patients consisted of two showers and scrubbing with a 4% chlorhexidine detergent solution the hair on the chest and leg was cut the night before surgery. In the operating room, the skin was scrubbed with 4% chlorhexidine solution followed by desinfection with 0.5% chlorhexidine in 70% ethanol. Cloxacillin, two grammes three times a day, was administered intravenously six times. The first dose was started one hour prior to the skin incision. The surgical procedures were performed in an operating room with ultra clean air with <10 Colony Forming Units (CFU)/m^3 [50]. The staff wore tightly woven scrub suits, which prevented bacteria from the skin flora to be released into the air [51].

Data analysis

Quantitative analysis

The presences of possible predictors for SWI were compared in patients with and without SWI. Nominal data were analysed using the X^2 test. The Kolmogorov-Smirnov goodness-of-fit test was used to analyse data distribution for the remaining risk factors. If distributions deviated significantly ($p < 0.05$) from the normal distribution the data were analysed using the Mann-Whitney U or Kruskal-Wallis tests. Those variables not deviating from the normal distribution were analysed using Student's t-test or one-sided ANOVA. Continuos variables are given as mean ± SD, categorical variables as percentages. Some data were further analysed with a logistic regression analysis. All calculations were made using SPSS (Statistical Package for Social Sciences) version 12.0.1.

Qualitative analysis

Interviews were analysed utilising a qualitative content analysis methodology [82, 83]. The procedure and concepts used followed the suggestions by Graneheim and Lundman [84]. In the manifest content analysis, the written words are used as a base for the analysis. In the latent content analysis, the aim is to find underlying meanings in the text [85]. All tape-recorded interviews were transcribed verbatim. Each transcript was read and re-read several times. Words and phrases comprising "meaning units", which referred to similar topics, were grouped together, in order to categorise the answers. The analysis of the text first describes these visible, obvious components, the manifest content [82, 83]. Meaning units were condensed into categories. A category answers the question "what?" [84]. The underlying meanings of the categories, the latent content, are then described in themes. A theme answers the question "how?". A theme is a common underlying meaning of categories on an interpretative level [84]. Extensive discussions among the co-authors concerning the logic and consistence of the classification contributed towards a broad agreement on the relevance of the coding system and the stability of the emerging themes.

The credibility (validity) in qualitative methods refers to the confidence in the truth of the data [86]. For a high credibility it is important to show that the

analysis has followed a clearly described qualitative method, that the interviews were performed in a standardised format and that it is possible to follow decisions throughout the analysis [84].

The dependability (reliability) refers to the stability of data over time and alterations made in the researcher's decisions during the process of analysis [84]. It is important to have extensive discussions within the research group concerning the logic and consistency of the classification [84].

It is the reader's decision whether or not the findings are transferable to another context [84]. To facilitate the transferability (generalizability) it is essential to give a clear and precise description of culture and context, selection and characteristics of participants, data collection and process of analysis.

Summary of findings

Incidence of SWI and identification of risk factors for SWI

SWI were diagnosed in 113 of 374 (30,2 %) of the patients. In total SWI were diagnosed in 120 surgical site incisions. Sixty-three (17.7%) patients had leg infections, 45 (12.0%) had superficial sternum infections and 12 (3.2%) cases of mediastinitis were diagnosed within 60 days of surgery. Almost all SWIs on the sternum (93.3%) were diagnosed within 30 days of surgery. Most of the SWIs on the leg (73%) were diagnosed within 30 days of surgery but 27% were diagnosed within 31 to 60 days of surgery.

Patients with SWI on the leg were more often female and had lower preoperative haemoglobin concentrations than those without infections. The preoperative duration of hospital stay was longer in patients with infection. The intraoperative risk factor cardiopulmonary by-pass time was longer in patients with infections. Of the postoperative risk factors haemoglobin concentration on postoperative day 2 was lower in infected patients. Also, the patients with infections had more often received erythrocyte transfusions on postoperative day 1. When infections were subdivided into early (day 0-30) and late (day 31-60) infections new risk factors for late infections emerged. The number of Saphenous vein grafts, the number of internal mammary artery grafts, the duration of aortic cross clamping time and the number of scrubbed persons present in the operating theatre during surgery, differed between early and late SWI. Also, patients with late infections had more often low haemoglobin concentration on day 1 and they had received erythrocyte transfusions on postoperative day 2 or later more frequently.

Patients with SWI on the sternum had higher BMI, more often diabetes and lower preoperative haemoglobin concentrations than those without infections. Of the postoperative risk factors, reoperation on sternum, number of days in ICU, postoperative haemoglobin concentrations day 2 and erythrocyte transfusions on postoperative day 1 differed significantly between patients with and without infections.

Patients with mediastinitis had higher BMI than those without such infections. Patients with mediastinitis more often had received erythrocyte transfusions on postoperative day 2 or later than those without infections.

Preoperative haemoglobin concentration as a risk factor for SWI was further analysed in a logistic regression analysis (Table 7). Patients were

grouped into those above and below the average preoperative haemoglobin concentrations 140 g/l. The odds ratio (OR) for an early leg SWI was not significantly increased by a low preoperative haemoglobin concentration. The uncorrected OR for low haemoglobin concentration as a risk factor for a late leg SWI was 3.59 (95% confidence interval (CI) 1.23-10.5; p=0.019) but did not remain significant when corrected for gender. The uncorrected OR for low preoperative haemoglobin concentration as a risk factor for superficial SWI on the sternum was 3.01 (CI 1.55-5.84; p=0.001). When corrected for BMI, diabetes, gender, age, postoperative haemoglobin concentration on day 1, CPB and reoperation on sternum, the OR increased to 4.16 (CI 1.80-9.62; p=0.001).

Table 7. Preoperative haemoglobin concentration as a risk factor for development of surgical wound infections following coronary artery bypass grafting operation

	Patients with infections (%)		Uncorrected			Corrected		
	Hb < 140 g/l	Hb ≥ 140 g/l	OR	95% CI	p	OR	95% CI	p
Any leg wound infection	35/152 (23.0)	28/203 (13.8)	1.87	(1.08-3.22)	0.026	1.36[1]	(0.75-2.46)	0.312
Early leg wound infection	23/152 (15.1)	23/203 (11.3)	1.40	(0.75-2.60)	0.293	-	-	-
Late leg wound infection	12/129 (9.3)	5/180 (2.7)	3..59	(1.23-10.5)	0.019	2.91[1]	(0.95-8.89)	0.061
Superficial sternal wound infection	29/153 (19.0)	15/208 (7.2)	3.01	(1.55-5.84)	0.001	4.16[2]	(1.80-9.62)	0.001

OR – odds ratio
CI – confidence interval
[1] corrected for gender
[2] corrected for BMI (kg/m^2), diabetes, gender, age, postoperative haemoglobin concentrations day 1, cardiopulmonary by-pass time and reoperation on sternum

Postoperative blood glucose control as a risk factor

Of the patient related risk factors patients with diabetes differed from those without diabetes with respect to BMI, current smoking status, preoperative haemoglobin and serum creatinine concentrations. Of the intraoperative risk factors they differed in the number of Saphenous vein grafts used, number of IMA used and duration of leg operation. Of the postoperative risk factors they differed in number of days in ICU and postoperative haemoglobin levels day one and day three.

Among all patients without or with diabetes mean blood glucose concentration were compered day zero, one and two. In patients without diabetes, those with mediastinitis had significantly higher blood glucose concentra-

tions on day zero, one and two, but there were no other differences in patients with and without infections.

Infections at the different sites were entered as outcome variables in logistic regression analyses. When diabetes was entered as an independent variable there was a significance association with any infection irrespective of its site and with superficial sternum infection. As a second steep blood glucose concentration day zero, one and two were added to the models. The blood glucose concentrations were not associated with infection outcome at any site. The diagnosis diabetes remained a risk factor for any infection irrespective of site (OR 2.48; CI 1.20-5.15; p=0.014) and for leg infection (OR 3.79; CI 1.49-10.07; p=0.007). For superficial sternum infection diabetes did not quite reach significance as a risk factor (OR 2.85; CI 0.99-8.19; p=0.052). In these analyses mediastinitis was not related to diabetes or to blood glucose concentration.

For patients without diabetes, mediastinitis was entered as the outcome variable (Table 8). The OR for developing mediastinitis was 1.36 (CI 1.03-1.79; p=0.032) for a one-unit change in blood glucose concentration day zero. When correcting for age, gender, BMI, current smoking, preoperative haemoglobin and creatinine concentrations the OR increased to 1,91 (CI 1.09-3.34; p=0.023). The OR for developing mediastinitis was 1,54 (CI 1,11-2,15; p=0,011) for a one-unit change in blood glucose concentration day one. When correcting for age, gender, BMI, current smoking, preoperative haemoglobin and creatinine concentration the OR increased to 1.63 (CI 1.07-2.50; p=0.024). The OR for developing mediastinitis was 1.42 (CI 1.01-2.01; p=0.047) for a one-unit change in blood glucose concentration day two. When correcting for age, gender, BMI, current smoking, preoperative haemoglobin and creatinine concentration the OR increased to 3.57 (CI 1.08-11.76; p=0.036).

Table 8. Postoperative blood glucose concentration as a risk factor for development of mediastinitis following coronary artery bypass grafting operation in patients without diabetes

	Uncorrected OR for mediastinitis			OR for mediastinitis corrected for age, gender, BMI, current smoking, preoperative hemoglobin and creatinine concentrations		
	OR	95% CI	p	OR	95% CI	p
Blood glucose concentration day 0	1,36	1,03-1,79	0,032*	1,91	1,09-3,34	0,023
Blood glucose concentration day 1	1,54	1,11-2,15	0,011*	1,63	1,07-2,50	0,024
Blood glucose concentration day 2	1,42	1,01-2,01	0,047*	3,57	1,08-11,76	0,036

OR – odds ratio
CI – confidence interval

Risk factors for SWI in the Saphenous vein harvesting leg

Twohundred and seventy-five men and 81 women with a mean age of 65.78 ± 8.35 (range 38-85 years) underwent CABG with Saphenous vein harvesting. SWIs were diagnosed in 63/356 (17.7%) leg wound incisions. Of the leg incisions with SWIs 17.5% were located on the calf, 30.2% on the calf/knee, 50.8% on the calf/ knee/thigh, and 1.6% on the calf/knee/thigh/groin. The incidence of SWI was not related to the extension and position of the incision. However, at the telephone follow-up 30 and 60 days after the CABG procedure the most frequently reported position of the SWI was on the calf ($p<0.001$).

Twenty-seven patients had bilateral leg incisions and 7 (12.5%), of these had SWIs, leaving 56 patients with SWI. Before discharge, 8.4 ± 3.9 days after surgery, SWIs has been diagnosed in 12 leg incisions. In these leg incisions two SWIs were on the medial calf, 3 on the calf/knee and 7 on the calf/ knee/thigh. The incidence of such early-diagnosed SWI was not related to the site or extent of the incision.

The patient-related risk factors female gender and low preoperative haemoglobin concentration were more common in patients with leg infections than in those without infections. The intra-operative risk factor duration of cardiopulmonary by-pass time was longer in the infected patients. Of the risk factors related to vein harvesting, the use of a drain was more common among patients with infections. However, the use of a clip for vein stump closure at the medial malleolus was more common among patients without infections. With regard to suture technique, separate sutures for tissue flaps following excision of the Saphenous vein were more common in patients with infections than in those without. Patients whose wounds were closed with running intracutaneous monofilament glycomer 4-0 (Biosyn®) or interrupted monofilament nylon 3-0 (Ethilon®) more often had SWIs.

The clinical wound evaluation on postoperative day four showed that wound gap was associated with leg infection ($p=0.007$) within 60 days of surgery. Patients with wound gap at the 30 day telephone interview more often reported pain in the leg ($p=0.014$), erythema ($p=0.008$), oedema ($p=0.007$) around the incision, and were more sensitive to touch ($p<0.001$). Signs such as bleeding, haematoma, oedema, serous discharge, local rise of temperature, and erythema defined at the clinical wound evaluation were not associated with subsequent wound infection, nor did these signs predict symptoms of pain, erythema, oedema or sensitivity to touch at the telephone interview. There was no difference between the number of clinical signs at the photo evaluation between patients with or without SWI. None of the above signs at the photo evaluation was associated with wound infection of the vein harvest leg. The agreement between the assessed presence or absence of wound gap (76%), bleeding (79%) and erythema (84%) at the clinical wound evaluation and the photo evaluation was acceptable. The agreement for heamatoma (51%) was poor [87]. Oedema, serous discharge, local rise in temperature and pain were not possible to assess at the photo evaluation.

One hundred and seventy-six patients were randomly assigned to an absorbent dressing and 180 to a hydrogel dressing (Elasto-Gel®) on the leg incision. Nineteen patients had the dressing changed from the assigned type before the clinical inspection on postoperative day four, usually due to bleeding. On postoperative day four, 171 had an absorbent dressing and 166 had a hydrogel dressing. Nineteen percent of the patients with an absorbent dressing, 18% of the patients with a hydrogel and 5% of the patients who had had the type of dressing changed had SWIs. There was no significant association between leg infections and the type of dressing used. In those with SWI there was no difference in species of bacteria when the types of dressings were compared.

The use of intracutaneous monofilament glycomer 4-0 (Biosyn®) for wound closing, as a risk factor for SWI was further analysed in a logistic regression analysis (Table 9). When this suture and technique was entered as an independent variable there was a significant association with leg infection

(OR 3.03; CI 1.47-6.23; p= 0.003). As a second step the use of a drain, separate sutures for tissue flaps following excision of the Saphenous vein, use of monofilament nylon 3-0 Ethilon®, use of a clip at the medial malleolus, duration of cardiopulmonary by-pass time, preoperative haemoglobin concentrations, wound gap at clinical wound inspection on postoperative day four and gender were added to the model. Even then, wound closure with running intracutaneous monofilament glycomer 4-0 (Biosyn®) remained as a risk factor for SWI of the leg (OR 5.64; CI 2.36 – 13.48; p<0.001), while the other risk factors did not predict SWI.

Table 9. Relationship between running intracutaneous monofilament glycomer 4-0 (Biosyn®) and vein harvesting techniques and gender as risk factors for development of postoperative wound infections following a coronary artery bypass graft operation in 356 patients.

Outcome		**OR**	**95% CI**	**p**		**OR**	**95% CI**	**p**
Leg infection	Running intracutaneous monofilament glycomer 4-0 (Biosyn®)	3.03	1.47-6.23	0.003	Running intracutaneous monofilament glycomer 4-0 (Biosyn®)	5.64	2.36 – 13.48	0.000
					Drain	2.33	0.71 – 7.63	0.162
					Tissue flap – seperate sutures for keeping the tissue flap together	0.98	0.85 - 1.12	0.726
					Monofilament nylon 3-0 (Ethilon®)	1.93	0.37 – 9.94	0.434
					Use of clip at medial malleolus	0.12	0.01 – 1.05	0.055
					Duration of cardiopulmonary by-pass time (CPB) (min)	1.00	1.00 – 1.01	0.383
					Preoperative haemoglobin concentrations (g/L)	1.00	0.96 – 1.02	0.510
					Wound gap	0.64	0.26 – 1.57	0.326
					Gender	2.07	0.91 – 4.72	0.084

OR – odds ratio
CI – confidence interval

Patients' experiences of mediastinitis

Content analysis revealed three themes with regard to the patient's experiences, how they coped to manage the mediastinitis and how they thought it would influence their future life (Table 10). A first theme centred around the physical and psychological discomfort and the impact on autonomy. The staffs' medical knowledge and the quality of nursing care as well as the patients' understanding of the situation influenced their experiences.

> "When a patient is lying there crying and they don't even come in, they just walk past…I think…you're so vulnerable when you get back. The thoughts just spin through your head when they say this and that. They prescribe lots of medications. Then you know that something's not good. I think that's unfortunate. Maybe they could have come in and explained." (Woman, aged 61)

A second theme was how perceived danger and stress affected how patients dealt with their situation. The patients used active coping, such as problem solving and information seeking to deal with their situation.

> "I was obsessed that if it wasn't clean I would get more. I lay and watched the staff. I always had a mirror with me, I wouldn't let it go. I wanted to be in control and have a good view of the wound." (Woman, aged 65)

They also attempted to change their way of thinking by dissociation, distraction and minimising the problems or by expressions of emotion.

> "They had talked to me earlier, I was a bit prepared that I had an infection, but I didn't understand how it would feel. When they talked to me about it I still had my friends around. We got to know each other well. I actually made several new friends that I still talk to over the phone." (Man, aged 59)

The third theme covered the patients' belief that the mediastinitis would not affect the outcome of the CABG procedure, although their confidence in this was influenced by uncertainties about the rehabilitation process.

> "Despite all the difficulties I would do the same again. Even if I knew I would get an infection I would go through it again. Now I can see how bad it's been during the last few years." (Woman, 56)

One category remained on category level; the patients' feelings towards their local hospital were influenced by experiences during the period before the mediastinitis was diagnosed.

Table 10. Themes, categories and category contents of patients' experiences of mediastinitis following coronary artery bypass grafting operation.

Theme	Category	Central characteristic of the category
Physical and psychological discomfort and the impact on autonomy were influenced by the care providers' medical knowledge, how nursing care was performed and the patients' understanding of the situation	The meaning of knowledge	Statements regarding how the medical knowledge of the staff and the provision of information are perceived.
	The meaning of nursing care	Statements referring to how the performance of nursing care was perceived; being seen as an individual and desiring support.
	Physical and psychological limitations during the treatment	Statements referring to physical and psychological limitations and limited recollection.
	Physical and psychological discomfort during the treatment	Statements referring to feelings of low priority, physical and psychological discomfort connected with food and elimination, general anaesthesia during PFD dressing change, pain, hallucination, vacuum assisted closure therapy, fear and general discomfort.
Perceived danger and stress influenced how the patient handled their situation	Struggling to take control of the situation	Statements about patients' own experience and knowledge, seeking information from others with personal experience, active measures, maintaining control, self care, problem solving, having goals and social support.
	Avoiding problems by changing the way one thinks or feels about the situation	Statements about dissociation, distraction and minimisation of problems.
	Emotional reactions based on feelings	Statements about expression of emotion.
The patient believed that the mediastinitis would not affect the outcome of the CABG procedure, although their confidence in this was influenced by uncertainties about the rehabilitation process	No effect on the coronary artery bypass graft procedure	Statements about no effect

	Feeling insecure about the rehabilitation process	Statements about feeling insecure about whether the infection is eradicated and about the duration of rehabilitation
	Influence on the relationship with the local hospital	Statements about negative feelings towards the local hospital

Discussion

The general aim of this thesis was to establish the incidence of SWI after vein harvesting on the leg and after sternotomy following CABG procedure. Clearly outlined, clinical criteria were used together with an extended period of follow-up and a defined follow-up procedure. The incidence of SWI in Study I was as high as 30,2 %. This observation and the results of Tegnell et al. [4] indicate that the incidence of SWI after CABG is higher than previously reported [5, 11-42]. A possible explanation of this may be that the meticulous, extended follow-up, individual instruction of the patients with regard to signs and symptoms of SWI and the low drop-out rate led to few undiagnosed infections. This was possible with self-report of symptoms and signs of SWI provided the patient were instructed before discharge. Indeed, most of the infections were confirmed by cultures. The literature reviewed [5, 11-42] revealed difficulties when different studies of postoperative infection incidence were compared. All studies do not provide a detailed definition of SWI, the clinical setting, the previously known risk factors, the possible risk factors studied, follow-up time and how follow-up was performed. However, it has been possible to perform multicentre collaborative surveillance when standardised definitions of SWI, risk adjustment and reporting methodology were used [41, 49]. Standardised methodology is of great importance for the quality and the reliability of the surveillance of infection.

The majority of the studies reviewed used a definition of infection based on the CDC definition. This definition is, however, wide and open to interpretation. The symptoms and signs indicating infection must therefore be defined but this is usually not done. The CDC definition includes the presence of purulent discharge from the wound. Infections caused by Coagulas-Negative Staphylococci (CoNS) may have only few clinical signs and symptoms. Tammelin et al. therefore has suggested a microbiological definition of SWI [88] as an alternative/complement to a clinical one. The studies reviewed have not considered this possibility of using different alternatives for defining SWI.

Most of the studies reviewed [5, 11-31, 33, 34] are large retrospective studies with populations up to >10000 patients. Data are collected from national databases for open-heart surgery and from patient records. The collected data are often previously known as risk factors and the majority are simple measures that can easily can be found in databases and records. Descriptions of the clinical setting, the duration of follow-up and procedures are not avail-

able in the studies. As showed in Study I, there is probably other risk factors in the setting that influence the incidence of infection. Most of the infections recorded in the review were on patients who were readmitted to hospital because of reoperation and/or treatment for severe postoperative wound infections. Postoperative wound infections, which were not as severe, may have been handled elsewhere and not included in the registration. The degree of ascertainment will therefore be higher for mediastinitis then for postoperative wound infections of the leg. This is supported by a high agreement on the incidence of mediastinitis compared to the wide range of reported incidence of SWI of the leg. Some studies suggested different risk factors for mediastinitis and leg wound infections. This conclusion may however not be correct if the degree of ascertainment is different for mediastinitis and leg wound infections. A stricter follow-up of the leg infections would increase ascertainment and hence improve the analyses of risk factors.

Only seventeen of the studies reviewed were exclusively on patient undergoing CABG procedures. The other studies included patients who underwent valve replacements or aortic aneurysm surgery. Since these procedures leave the patients with implants, the risk factors for postoperative wound infections may be different. This has not always been considered in the analyses of groups of patients who have undergone different procedures.

In the present studies the incidence of SWI varied between the three incision sites following a CABG procedure [I]. An attempt to identify independent risk factors for SWI at the different surgical-site incisions showed that female gender was an important risk factor for SWI of the leg. When this was further analysed [III] suturing technique appeared the most important risk factor after correction for other known risk factors including gender. The risk factors for late SWI on the leg indicated that this group of patients had had a longer and more complicated surgical procedure. This observation would have been unobserved if follow-up had not been extended beyond 30 days postoperatively.

Intraoperative risk factors associated with operating room hygiene in [I] did not appear to be risk factors for SWI. This is not to say that operating room hygiene is unimportant in this context. If operating rooms are technically equipped to maintain an ultraclean air environment and procedures not to disturb airflow or otherwise impair sterility are observed, the risk of SWI diminishes [89]. Since this is presently achieved, attention can be turned to other risk factors if the incidence of SWI is to be diminished. However, it is of great importance to have a continuously follow up of operating room hygiene in order to maintain a high standard.

A novel finding was also that a low preoperative haemoglobin concentration was the most important risk factor for superficial SWI on the sternum. It is conceivable that poor tissue oxygenation impairs wound healing and increases the risk for SWI. The destruction of vasculature by injury together with the accumulation of inflammatory cells reduces oxygen supply in the

wound, which in turn reduces the killing capacity of the granulocytes [90]. It is notable that even during an uncomplicated CABG procedure there is haemodilution, reduced body temperature during CPB, reduced blood pressure during CPB, blood loss and adrenergic vasoconstriction caused by pain, all which could diminish oxygen transport to peripheral tissues. Patients with a low preoperative haemoglobin concentration would then be at a further disadvantage when all the effects of the CABG procedure are added. Patients with mediastinitis had higher BMI and had more often received erythrocyte transfusions on postoperative day two or later than those without infection. Also these patients my have had a diminished oxygen transport to peripheral tissues during the perioperative period which increased the incidence of SWI.

Different risk factors emerged for the three different surgical sites. The risk factors were also different for early and late wound infections. In studies of SWI it is therefore important to analyse wounds separately and cover a wide range of both patient- and procedure specific risk factors [68].

Study II confirms the findings of diabetes as an important risk factor for SWI following CABG procedures [57, 58, 30, 91]. However, diabetes does not always emerge as a risk factor in the studies reviewed [5, 11-42]. One possible explanation of this is that the groups' "non-diabetic" patients include many with undiagnosed diabetes [57].

It is unclear whether it is hyperglycaemia as such or the diabetic state that confer an increased risk. In Study II it was not possible to separate the effect of diabetes as a risk factor from that of hyperglycaemia. In the subgroup of patients without a preoperative diagnosis of diabetes increased blood glucose concentrations during postoperative day zero, one and two was associated with an increased risk of mediastinitis but it is unclear whether some of them had undiagnosed diabetes preoperatively [65].

There may be separate effects on the postoperative hyperglycaemia and the longstanding disturbed metabolism of diabetes on the risk of SWI. High blood glucose as such could influence the systemic inflammatory response [92]. Hyperglycaemia also influences fluid and electrolyte balance, which disturbs hydration and circulation in the incision area, all which could impair wound healing. The longstanding effect of the deranged metabolism of diabetes causes disturbances of microcirculation in the skin and causes irreversible vascular damage [49], which could contribute to impaired wound healing and infection irrespective of the postoperative blood glucose concentration. Altogether, present and previous data suggest that perioperative hyperglycemia is a risk factor for SWI independent of diabetes. To really separate the effect of diabetes and hyperglycemia a correct preoperative identification of patients with diabetes would be necessary. Furthermore, to achieve separation a protocol for perioperative near-normal glycemia is required to avoid equation of hyperglycemia with diabetes [61].

The characteristic of the monofilament suture is that it is stiff and disobliging to knot. The leg suture is started at both proximal and distal ends of the incision. Where the two sutures meet at the middle, usually at mid-calf, a knot is inserted. It is important to have a good knot-tying technique and to embed the knot in the surrounding tissue to prevent the cut suture ends from piercing through skin or penetrating the wound incision. If the knot is not embedded in the surrounding tissue and there is a gap in the incision line, the knot and the remaining suture ends protrude. Bacteria may then adhere and cause infection. Wound gap would persist as long as the suture remains in the wound. Since the absorption time for glycomer 4-0 Biosyn® is 90-110 days [94] the suture would prolong the wound healing process and be a potential risk factor for SWI up to three months after surgery. Although fewer bacteria would adhere to a monofilament suture than to a braided suture [95] the prominent knot and the residual suture present a risk factor for SWI on the calf. Indeed, in previous study we showed that 27% of all SWIs on the vein harvest leg were diagnosed as late as the second month of follow-up.

Although the suture glycomer 4-0 Biosyn® was the most important risk factor for SWI, wound gap was able to predict SWI only in the clinical inspection. Oedema was not possible to assess on the photos because of the absence of a three-dimensional view. Serous discharge was also impossible to evaluate on the photos since the wound dressing could not be inspected. The presence of heamatoma failed to predict SWI but the lack of definition of a significant heamatoma precluded its use as a sign. The moderate agreement between the early clinical assessment and the photo inspection showed the difficulty in evaluating surgical wounds. Unfortunately, the wound evaluation scale used in this study had no precise definitions of the signs, nor of the extension of what constituted a significant heamatoma, which could explain the different outcomes of the clinical and the photo evaluation. In a review of the literature, three wound assessment scales for evaluation of surgical wound healing have been identified. The ASEPSIS wound scoring system [69] has definitions of the extent of the signs and the Southampton Wound Assessment Scale [73] has both definitions of the extent of signs and also defines the location of erythema. The DISINFECT scale defines also stages of normal wound healing and signs deviating from the normal wound healing process [75]. However, the sign heamatoma is included in the DISINFECT assessment scale. Hall et al. [70] showed that the ASEPSIS wound scoring system was able to predict SWI. The ASEPSIS wound scoring system has been used to evaluate sternal wounds following CABG [4, 69, 70]. It has the definitions of the extension of the signs required to consider them significant. The ASEPSIS wound scoring system can predict SWI [70]. However, it was developed for clinical trails evaluating antibiotic prophylaxis, is time consuming to administer, and its use is limited when patients are discharged early from hospital [70, 71]. Heamatoma has not been considered in this assessment scale. The Southampton wound assessment scale [73, 74] is a further de-

velopment of the ASEPSIS system and is used in community surveillance of complications. It is less extensive and easier to administer in routine clinical practice. However, it has not been used to predict SWI after CABG. Altogether, this shows the difficulty in establishing a wound assessment system. The ideal assessment scale should be applicable both in a hospital setting and following discharge, define stages of normal wound healing, and should be simple enough for patients to self-report. This would require clear definitions of signs that can predict SWI. In this respect, a sign such as wound gap is probably easier to define compared to erythema and heamatoma, which would require a trained eye to distinguish from normal wound healing. Further studies of well-defined signs are required to establish whether SWI can be predicted by inspection.

To correctly and effectively diagnose SWI serves several purposes. The patients get immediate and adequate medical care. With a high ascertainment of SWI a correct incidence and a correct identification of risk factors can be achieved. This is necessary if a wound surveillance protocol is to be used for quality control and quality improvement. However, surveillance alone does not reduce hospital-acquired infection. Data needs to be provided to the medical and nursing staff, and linked to preventive efforts.

Patients with a newly diagnosed nosocomial wound infection exist in an indeterminate state in between health and illness, cure and disease. Although the patients with mediastinitis have been treated for a heart condition by a successful CABG they are still sick and in need of treatment and care. The SWI is a complication not in line with the curative focus and outcome orientation of the health care environment. The patients are therefore without a clear designation or in a state of liminality [96] when the mediastinitis has been diagnosed. The mediastinitis my be considered a failure by the care providers since it is not the expected outcome of a CABG procedure which in turn could influence how the patients are treated. The patients themselves do not understand their illness or its severity but are aware that they have not yet gained the expected return to a new and improved state of health. They are considered polluting from the wound, dangerous to other patients and kept isolated on the ward. The wound discharge is a constant material evidence of this liminal state. There may thus be a combination of a change in attitude of the care providers and an uncertainty of the situation on the patients' part. As presently demonstrated the patients are then sensitive to how medical and nursing care is performed and prone to negative feelings and interpretations. The state of liminality would be relieved if the patients' new state is recognised by the care providers and the patients themselves are kept well informed. This would require routines for information and care of the patients and attitudinal changes of the care providers. In this context, it is important to emphasise the present finding of how information and professional ability correlated with the psychological well being of the patients.

The observation that the patients' experiences did not effect the final outcome of the CABG procedure should not allow the conclusion that these experiences are acceptable or of minor importance. The significance of such negative experiences may bee overlooked since an anticipation of a final outcome may reduce stress in an otherwise difficult situation [97]. Indeed, the full impact of negative experiences is not revealed by the present investigation in view of that several patients declined participation, feeling not being ready to talk about what they had been through.

Methodological considerations

A strength of the studies [I, II, III] was that when patients were recruited as many as 97% of those approached agreed to participate. Of the 396 patients included, 374 (94%) participated in the post-discharge follow-up. Of those not followed-up only four were lost because they could not be located. Thus, the sample of patients was assumed to be representative for patients undergoing CABG, with the exception that the proportion of patients with diabetes in the sample was as high as 49%. It was furthermore possible to collect a full risk factor profile for almost all patients.

Patients were recruited for the studies [I, II, III, IV] over an extended period 1998-2005 with intermittent periods without recruitment. However, during this period there was no major change in CABG procedures. VAC treatment of mediastinitis was a standard procedure from 2001.

The SWI were self-diagnosed and self-reported by the patients [I, II, III]. There may then be a risk of both over- and underestimation of SWI. Patients were, however, individually taught signs and symptoms of SWI, were asked to make notes of such and were given instructions about the surveillance questionnaire and the telephone interviews before discharge from the hospital. The patients in the present study were thus well prepared not to overlook signs of SWI. Seventy percent of the SWIs in patients with early infection and 53% of the SWIs in patients with late infection of the leg were also confirmed by bacterial cultures in order to establish SWI.

The timing and number of blood sugar samples varied between patients and were dependent on unprecise clinical routines [II]. It was not possible to relate the blood glucose sampling to meals and in patients with few samples the averaged value may be less representative. This is a type of limitation inherent in all observational studies of clinical practice.

The wound evaluation scale used [III] lacked precise definitions of the signs and of the extension of what constituted a significant heamatoma, erythema etc. The wound evaluation was also dependent on the nurses' and nursing aids' knowledge of normal wound healing and their ability to evaluate surgical wounds. In its present form the scale is of little use in predicting SWI.

There is a possible weakness in Study IV in that pre-understanding of the context may influence the analysis. The strength of the trustworthiness of the material was established in that all patients were asked the same three open-ended questions. Inter-coder reliability was achieved by extensive discussions among the co-authors, which would minimise the bias of pre-understanding. Two of the participants had their wives nearby during the interview. This is not desirable and could have influenced the patients' narratives.

Conclusions and further directions

This thesis indicate several areas of medical and nursing care, which influence the incidence of SWI and the patients' perspective of SWI. Interventions in these areas would then be expected to reduce the incidence of SWI and improve the patients' experiences. However, an effective surveillance system is required to successfully implement and evaluate changes of routines.

This must include registration of the major well-documented risk factors for SWI, control of adherence to treatment protocols followed by meticulous registration of SWI and follow-up of patients' perspectives. For patients undergoing CABG this constitutes an administrative challenge since they often are referred from other hospitals to which they subsequently return for further postoperative care. Complications such as SWI are then not diagnosed and treated by the Department of Cardiothoracic Surgery. The surveillance would thus require an effective administrative system for data collection and processing.

A broad agreement among care providers of the importance of surveillance is necessary if the system is to perform well. If the system provides effective feedback without undue delay this is likely to enhance performance.

It is thus a combination of well-grounded interventions and adequate surveillance that can improve medical and nursing care.

> "Despite all the difficulties I would do the same again. Even if I knew I would get an infection I would go through it again. Now I can see how bad it's been during the last few years."
>
> Quote from a woman aged 56

Most of the patients had had symptoms of angina pectoris for several years before surgery. They were satisfied with the final outcome of the procedures since they did not experience these symptoms any more. The negative experiences of an infection may therefore be overlooked. Nevertheless, physical and psychological suffering could have been diminished. The patients' feelings of low priority and helplessness must be acknowledged and routines for information improved in order to reduce perceived stress and improve coping.

Clinical implications

- Establish routines for identifying risk factors for SWI, which could be modified/treated before the operation. This could be done either at the local hospital or patients could come to the Department of Cardiothoracic Surgery for a preoperative evaluation. Risk factors to be evaluated could be female/male gender, overweight, blood haemoglobin concentration and the presence of diabetes.
- Establish routines for blood glucose controls and maintenance of normoglycaemia during and after the operation irrespectively of whether they have diabetes or not.
- Establish routines for the early detection of decreasing blood haemoglobin concentrations, especially in patients with low preoperative values.
- Instruct medical staff at the local hospitals of symptoms and signs of mediastinitis.
- Establish routines for information to patients with mediastinitis in order to reduce perceived stress.

Suggestions for further research

- To examine if a preoperative risk assessment of the circulation in the proposed Saphenous vein harvest leg, an active decision on the position of the wound incision and a standardised suturing technique could decrease the number of SWI in the leg.
- To investigate the postoperative peripheral circulation in the Saphenous vein harvested leg the first postoperative 24 hours and relate it to the incidence of SWI.
- To examine if existing wound assessment scales could be used to predict SWI.
- To examine if improved routines for information to patients with mediastinitis could change percieved stress and coping.

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Uppsala in September 2006
Christine Leo Swenne

Sammanfattning

Det övergripande syftet med avhandlingen var att registrera antalet sårinfektioner i operationssnittet på bröstkorgen och på benet där venen opererats ut och studera möjliga riskfaktorer för sårinfektion. Ett andra syfte var att beskriva patienters upplevelse av att drabbas av en mediastint och av behandlingen.

Kända och möjliga riskfaktorer registrerades på 374 patienter. Patienterna telefonintervjuades med en strukturerad enkät om symtom och tecken på postoperativa sårinfektioner 30 och 60 dagar efter operation. Sårinfektion definierades enligt The Centers for Disease Control. Patienter som hade fått en mediastinit intervjuades också inom fyra månader om upplevelser av vården, hur de hanterade stress och hot och hur de trodde att sårinfektionen skulle påverka livet framöver.

Trettio procent av patienterna fick en postoperativ sårinfektion. Sjuttiotre procent av sårinfektionerna diagnostiserades inom 30 dagar efter kriurgi och 27% diagnostiserades mellan 31-60 dagar efter kirurgi. Kvinnligt kön var den viktigaste riskfaktorn för sårinfektion på benet. När riskfaktorer för sårinfektion på benet analyserades ytterligare var hudsuturen monofilament den viktigaste riskfaktorn för sårinfektion på benet. Låg preoperativ hemoglobinkoncentration var den viktigaste riskfaktorn för ytlig sårinfektion på bröstkorgen. Patienter som fick mediastinit hade oftare högt BMI och de hade oftare fått blodtransfusion postoperativt dygn 2 eller senare än patienter utan sårinfektion. Patienter utan diagnosen diabetes som hade högt blodsocker under det postoperativa förloppet fick oftare mediastinit. Det gick inte att separera effekten av diabetessjukdomen och högt postoperativt-blodsocker som olika riskfaktor för sårinfektion. Patienternas erfarenheter påverkades av sjukvårdspersonalens kunskaper, omvårdnaden och patientens förståelse av situationen. Hur patienterna hanterade sin situation påverkades av deras upplevelse av fara och stress. Patienterna trodde inte att den djupa sårinfektionen i bröstbenet skulle påverka resultatet av kranskärlsoperationen, även om oklarheter om rehabiliteringen påverkade deras tillit. Det är viktigt med lång uppföljning för att kunna spåra alla postoperativa sårinfektioner. Olika riskfaktorer för sårinfektion var viktiga beroende på vilket operationsnitt som var infekterat. Patientens upplevelser påverkades av sjukvårdspersonalens kunskaper, omvårdnaden och patientens förståelse av situationen. Upplevelsen av fara och stress påverkade hur de hanterade situationen.

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