The Impact of Surgical Wound Bacterial Colonization on the Incidence of Surgical Site Infection After Lower Limb Vascular Surgery: A Prospective Observational Study

J. Turtiainen [a,*], **T. Hakala** [a], **T. Hakkarainen** [a], **J. Karhukorpi** [b]

[a] Department of Thoracic and Vascular Surgery, North Karelia Central Hospital, Joensuu, Finland
[b] Department of Microbiology, Eastern Finland Laboratory Centre (ISLAB), Joensuu, Finland

WHAT THIS PAPER ADDS

This study investigated the relationship between surgical wound bacterial colonization and the development of surgical wound infection after lower limb vascular surgery. The study revealed that a high bacterial load in the surgical wound postoperatively independently increases the risk of the development of surgical site infection after lower limb vascular surgery.

Objective: To study the relationship between surgical wound bacterial colonization and the development of surgical site infection (SSI) after lower limb vascular surgery. SSI is a major problem after lower limb vascular surgery. Most SSIs in vascular surgery are caused by *Staphylococcal* species that are part of normal skin flora. A prospective observational investigator blind study to examine quantitative and qualitative analysis of surgical wound bacterial colonization and the correlation with the development of SSI has been conducted.

Methods: The study cohort comprised 94 consecutive patients with 100 surgical procedures. Swabs for microbiological analyses were taken from surgical wounds at four different time intervals: before surgery, just before the surgical area had been scrubbed, at the end of surgery, and on the first and second postoperative days. Postoperative complications were recorded.

Results: Three hundred and eighty-seven skin bacterial samples from 100 surgical wounds were analyzed. The most common bacteria isolated were coagulase-negative staphylococci (80%), *Corynebacterium* species (25%), and *Propionibacterium* species (15%). In 13 (62%) cases, the same bacterial isolates were found in the perioperative study samples as in the infected wounds. The incidence of SSI was 21%. Multivariate analysis revealed that high bacterial load on the second postoperative day and diabetes independently increased the risk of SSI. Elective redo surgery was protective against the development of SSI.

Conclusions: A high bacterial load in the postoperative surgical wound independently increases the risk of the development of SSI after lower limb vascular surgery.

Article history: Received 14 August 2013, Accepted 30 December 2013, Available online 7 February 2014

Keywords: Peripheral vascular surgery, Bacterial colonization, Surgical site infection

INTRODUCTION

Surgical site infection (SSI) is a major problem particularly after peripheral vascular surgery. SSIs increase the cost of vascular surgery and the risk of major amputations, as well as the mortality.[1–3] The incidence of SSI in patients undergoing peripheral vascular surgery procedures ranges from 4 to 27% according to prospective studies.[1,4–8]

The majority of SSIs in vascular surgery are caused by staphylococcal species that are part of the normal skin flora. *Staphylococcus aureus* has been reported to be responsible for 30–60%[1,3,7–10] and *Staphylococcus epidermidis* for 17–24%[9,10] of these infections.

A few studies have examined the relationship between the bacterial load of the surgical wound and the development of SSIs.[11–13] The aim of this study was to measure quantitatively and qualitatively the bacterial colonization of the surgical wound peri- and postoperatively, and to examine whether there was an association between bacterial load and the incidence of SSI in patients undergoing peripheral vascular surgery.

MATERIALS AND METHODS

Study design

The prospective descriptive study was conducted at the Department of Vascular Surgery, North Karelia Central Hospital. The data were collected between January and

* Corresponding author. J. Turtiainen, North Karelia Central Hospital, Tikkamäentie 16, 80220 Joensuu, Finland.
E-mail address: johanna.turtiainen@pkssk.fi (J. Turtiainen).

1078-5884/$ – see front matter
http://dx.doi.org/10.1016/j.ejvs.2013.12.025

October 2012. Swabs for microbiological analysis were taken from all surgical wounds peri- and postoperatively. Qualitative and quantitative analyses of various bacterial species were performed at Eastern Finland Laboratory Centre, Regional Laboratory of Joensuu. Blinded microbiological analyses were performed by an investigator who remained unaware of the origins of the coded bacterial samples. The study was approved by the ethics committee of Kuopio University Hospital (no. 100/2011, approved 3 November 2011). Written informed consent was obtained for every patient. The study was registered with ClinicalTrials.gov (no NCT01505738).

Patients

Consecutive adult patients undergoing non-emergency lower limb revascularization surgery were included in the study. The exclusion criteria were patients' refusal to participate, patients' inability to give informed consent, antibiotic treatment in the 2 weeks prior to surgery, or cephalosporin allergy. Aorto-iliac procedures were not included in the study. Incision drapes were not used in any procedures.

One hundred and nineteen patients underwent lower limb revascularization surgery during the study period. Altogether, 94 patients having 100 surgical procedures were included. Reasons for exclusion from the study were: patient underwent surgery at night or during the weekend when it was not possible to analyze the bacterial samples (92%); patient was receiving antibiotic treatment (4%); or patient was allergic to cephalosporin (4%).

Magnetic resonance imaging (MRI) or intra-arterial digital subtraction angiography by experienced angiographers was used for peripheral arterial disease evaluation. Data, including demographic characteristics and peri- and postoperative factors, were collected prospectively. A standardized antibiotic prophylaxis of 3 g of cefuroxime was administered within the hour before incision. A further dose of 1.5 g of cefuroxime was administered if the blood loss was $>$1,500 mL or if the operation took more than 4 hours.

Blood pressure, pulse, fingertip oxygen saturation, and blood glucose level were measured twice daily, and the number of blood white cells, the hemoglobin value, and the C-reactive protein value once a day for two postoperative days.

Development of postoperative wound infections and other postoperative complications were recorded. Surgical wounds were examined at the 1-month follow-up visit by a vascular surgeon. Patients with postoperative surgical wound infections were followed up until the wound had healed.

Variables

The main outcome in this study was whether a patient developed SSI. A wound complication was considered to be an infection if it met the criteria developed by the Centers for Disease Control and prevention (CDC).[14] The criteria were as follows: bacteria isolated from the wound or areas of localized redness, and heat, swelling and pain around the wound, appearing within 30 days of the operative procedure. The classification of SSI into three categories was based on the CDC criteria: a superficial wound infection involves only skin and subcutaneous tissue, a deep wound infection involves both fascia and muscle layers, and a graft infection is defined as the involvement of an artery or a graft.[14] The general complications, including pneumonia, cardiac complications, strokes, major amputations, and graft thromboses, were considered as secondary outcomes.

These complications were defined as follows:

- Pneumonia—infection of lung diagnosed by pulmonologist with correlative changes in chest X-ray film
- Cardiac complications—ischemic changes in electrocardiogram (ECG) with serum troponin-T value $>$0.5 μg/L or a new Q-wave or atrial fibrillation on ECG, or clinical diagnosis of cardiac insufficiency with correlative radiographic findings
- Stroke—one of the following symptoms: an inability to move limbs on one side of the body, inability to formulate or understand speech, or inability to see one side of the visual field with correlative changes at computed tomography or MRI
- Major amputation—above- or below-knee amputation
- Graft thrombosis—occlusion of revascularized native artery or vein, or prosthetic graft.

Sampling methods

A modified swabbing technique was used in this study. The specimen for bacterial culture was collected with the liquid-based Copan ESwab collection and transport system (Copan Italia, Brescia, Italy) by twirling the pre-wetted (0.9% sterile saline) nylon-flocked swab applicator with a sufficient pressure on the surgical site area of 2 cm $\times$ 4 cm for 30 seconds. The swabs were collected from the groin in 96 cases and from distal part of lower limb in four cases. If the revascularization surgery did not include the groin area, the swab was taken from the most proximal incision site. The applicator was placed on the ESwab transport tube containing 1 mL of modified liquid Amies (Copan Italia) according to the manufacturer's instructions.

Bacterial samples were collected at four different time intervals. Before surgery, the first sample was taken from the operative field just before the surgical area was scrubbed. At the end of surgery, the second sample was taken after suturing the wound and before the dressing was applied. Opsite-Post-Op dressings (Smith & Nephew Medical, Hull, UK) were used to cover the surgical wounds in all patients in the study. The third and fourth samples were taken directly from the wound on the first and the second postoperative days. The first two samples were taken in the operating room and last two in the surgical ward. An additional bacterial sample was taken from those surgical wounds that developed SSI.