Bacterial Adherence to Suture Materials

Brendan D. Masini, MD, Daniel J. Stinner, MD,* Scott M. Waterman, MD,† and Joseph C. Wenke, PhD‡*

*Brooke Army Medical Center, Ft Sam Houston, Texas, †Walter Reed Army Medical Center, Washington, DC, and ‡United States Army Institute of Surgical Research, Ft Sam Houston, Texas

BACKGROUND: Wound infections may be problematic for physicians. Whether a practitioner is managing complex penetrating trauma or a skin biopsy, there may be a need for suture closure. Suture material is an operator dependent variable and while little objective data exist to guide the choice of suture, it may play a role in wound infection. This study evaluates bacterial adherence to commonly used suture materials with a bioluminescent in vitro model.

METHODS: In all, 11 strands of size 2-0 poliglecaprone suture (Monocryl; Ethicon, Inc, Somerville, New Jersey), polypropylene suture (Prolene; Ethicon, Inc), silk suture (Ethicon, Inc), polyglycolic acid suture (Vicryl; Ethicon, Inc), and antimicrobial polyglycolic acid suture treated with triclosan (Vicryl*Plus*; Ethicon, Inc) were immersed in a broth of *Staphylococcus aureus* engineered to emit photons. After biofilm formation, the suture strands were irrigated and imaged with a photon-capturing camera system yielding a total photon count that correlates with residual bacteria.

RESULTS: The Vicryl suture had the highest counts and was statistically significant in bacterial adherence versus all other sutures. No other suture material was significantly different from any other.

CONCLUSIONS: This study gives data to guide the selection of suture materials. Absorbable braided suture should not be used in closure of contaminated wounds or wounds at risk for developing infection. The antibiotic impregnated absorbable braided suture was similar to the other suture types; however, it is at risk for reverting to the properties of its untreated counterpart over time. The bacterial adherence of suture materials should be taken into account by all practitioners when closing wounds or debriding infected wounds. (J Surg 68: 101-104. © 2011 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: suture, infection, bacterial adherence, wound complication

Correspondence: Inquiries to Brendan D. Masini, MD, Department of Orthopaedics and Rehabilitation, Brooke Army Medical Center, 3851 Roger Brooke Drive, Ft Sam Houston, TX 78234; fax: (210) 916-7323; e-mail: Brendan.Masini@amedd.army.mil

COMPETENCIES: Patient Care, Medical Knowledge, Practice Based Learning and Improvement

INTRODUCTION

Wound infections may be problematic for physicians. Whether a practitioner is managing complex penetrating trauma or a skin biopsy, there may be a need for suture closure. Suture material is an operator dependent variable, and although it may have a significant role in wound infection management, little objective data exist to guide material selection. Much of what we "know" about suture material selection is passed down as dogma in our surgical training programs without data-driven recommendations. We know that suture material is a foreign body that potentiates infection when implanted and that the ability of the sutured tissue to resist infection varies on the material implanted.[1] Suture functions to approximate tissue edges, which promotes healing and at the same time limits further deep contamination. Often, whether by the nature of a wound itself or by a later inoculation event, suture is present in a wound that has been exposed to a bacterial insult. The suture may potentiate the infection by harboring adherent bacteria. Previous studies have examined the bacterial adherence properties of sutures via methods, such as plate cultures, electron microscopy, and radiolabeling of bacteria, and have suggested that not only does bacterial adherence vary by the physical properties of the suture material but also that increased adherence of bacteria to suture directly correlates to the ability of that contaminated suture to cause a wound infection.[2,3]

The clinical problem addressed herein is one most basic to the practice of surgical medicine. In the course of wound management, suture may be required for closure of wounds at risk for contamination, or wounds that have been closed with the expectation of sterility may become contaminated or infected. Suture materials clearly cannot overcome sound surgical principles, such as thorough debridement and not closing contaminated wounds; however, knowledge of the behavior of bacteria on the surface of a suture material only enhances the surgeon's ability to make appropriate choices for the patient. The conflict present is the lack of clear recommendations from previous

literature to make a compelling argument in support of current surgical training dogma.

This study uses a novel imaging technique to quantify bacterial adherent to commonly used suture materials and we hypothesize that there will be an increase in bacterial adherence to polyglycolic acid sutures versus monofilament sutures.

MATERIALS AND METHODS

Suture Selection

The sutures selected for study were chosen to represent several common categories of suture material and basic construction properties. Poliglecaprone suture (Monocryl; Ethicon, Inc, Somerville, New Jersey), which is a copolymer of glycolide and epsilon-caprolactone, is a synthetic absorbable monofilament suture. It has been found to be nonantigenic and nonpyogenic, and it elicits slight tissue reaction during absorption. Polypropylene suture (Prolene; Ethicon, Inc) is a synthetic nonabsorbable monofilament. It has a high tensile strength and has been found to have minimal tissue reactivity. Silk suture (Ethicon, Inc) is a nonabsorbable suture composed of an organic protein called fibroin derived from the domesticated species *Bombyx mori*. The silk for the suture material is processed to remove the natural waxes and gums. Polyglycolic acid suture (Vicryl; Ethicon, Inc) is a synthetic absorbable braided suture composed of a copolymer made of 90% glycolide and 10% l-lactide. This family of sutures has been found to elicit only a slight tissue reaction during absorption. The antimicrobial polyglycolic acid suture (Vicryl*Plus*; Ethicon, Inc) has a triclosan antimicrobial coating to limit bacterial growth.

All sutures were size 2-0. They were obtained from commercially available, unexpired, sterilized packets. All sutures were taken directly from the package into the bacterial broth without additional machinations. Interventions, such as knot tying, abrasion with forceps or needle driver, or immersion in a serum broth to simulate an in vivo environment could all reasonably be expected to alter the bacterial adherence to the materials and were not performed in effort to maintain an environment that supported the ideal performance characteristics of each suture material.

Bioluminescent Bacteria

The bacterial broth prepared for this investigation consisted of 10^8 c.f.u./ml *Staphylococcus aureus* (lux) (Xenogen 29, Caliper Life Science, Hopkinton, MA). These bacteria are genetically engineered to emit photons, allowing for quantification with a photon-counting camera system. Bioluminescent bacteria emit light in proportion to their number allowing correlation of photon counts with bacterial counts.[4–6] Postinoculation plating of the broths was performed to confirm the consistency of concentrations in each batch prepared. The concentration selected for this study has previously been demonstrated to cause clinical infection in a large animal wound model in our laboratory and consistency in this area may facilitate future in vivo study of this question. It is greater than concentrations of bacteria that are found to cause infection in human models and thus represents a worst-case scenario for suture contamination. Sutures that demonstrate low bacterial adherence in this model can be expected to perform well in a wound where considerably less contamination would likely be present.

Inoculation

In all, 11 strands each of the suture materials were taken from the sterile, unopened, unexpired packages and cut into 10-cm strands. This was the width of our custom suture frame and also represented the image field for our camera system. The strands were immersed in the broth of bioluminescent *Staphylococcus aureus* (lux).

After 12 hours in the broth, sufficient time to allow biofilm formation,[7] the suture strands were removed individually from the broth and irrigated with 10 ml of normal saline expressed at low pressure from a syringe. In model development, broth immersion of 24 and 48 hours showed no greater bacterial adherence to the sutures. Also, this irrigation protocol was found in model testing to reproducibly remove nonadherent bacteria.

Quantification

Once removed from the broth and irrigated, the suture was suspended in a custom frame and placed within our dark-box for imaging. The IVIS100 imaging system (Xenogen Corporation, Alameda, California), uses an optical charge couple device camera to count photon emissions. Imaging software (LIVINGIMAGE V. 2.12; Xenogen Corporation and IGOR v.4.02A, WaveMetrics, Lake Oswego, Oregon) was used to superimpose the photon count onto a gray-scale background image yielding the location and photon intensity. A standard size region of interest (ROI) was placed around the suture on the image and from this ROI the total photon count was taken. This photon count correlates directly with the bacteria adherent to the suture material. This process was repeated for each suture with a rotating selection of each suture type from the broth to minimize any small difference that would exist between the times of exposure to the broth. Of note, only living bacteria continue to release photons. Nonviable bacteria even if present on the imaged sutures are not counted by our camera system.

Statistics

A 1-way analysis of variance was performed to compare means. When the PHYLIP null hypothesis of equal means was rejected, the Fisher least significant difference procedure was performed for pairwise comparisons of the groups. SAS Statistical Software (SAS, Inc, Cary, North Carolina) was used for all statistical calculations. The alpha was set as 0.05.