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Permacol Interposition Graft as an Alternative to Vein in Contaminated Wounds Using a Rabbit Model

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Background: Vascular injuries are common in trauma and often involve massive soft tissue injury and segmental arterial loss. Current practice uses either autogenous vein or polytetrafluoroethylene (PTFE) for interposition grafting in arterial injuries. Decision making between autogenous or synthetic conduit pivots around the physiological state of the trauma patient. Vein is known to increase operative times in an already physiologically depleted patient, whereas synthetic graft can be simply pulled from the shelf. However, when used in contaminated wounds, PTFE is prone to chronic infection and subsequent graft failure. An alternative synthetic conduit resistant to infection would be ideal for such situations. Permacol (Tissue Science Laboratories, Inc, Andover, MA), a biosynthetic material, has demonstrated resistance to bacterial contamination in contaminated hernia repairs. When fashioned into a tubular structure, this material may be useful as an alternative vascular conduit in contaminated trauma wounds.

Methods: New Zealand white rabbits were randomized to one of 4 groups: Permacol graft (P) without bacterial contamination ($n = 9$), Permacol graft with bacterial contamination (CP; $n = 9$), autogenous vein graft without bacterial contamination (V; $n = 9$), or autogenous vein with bacterial contamination (CV; $n = 9$). All groups then underwent interposition grafting of the right common carotid artery. Grafts were contaminated by applying *Staphylococcus aureus* (1×10^5 colonies/0.1 mL) directly to the exposed surface of the graft on completion of the arterial repair. Each graft was then excised at day 42, and segments were collected for histologic evaluation, bacterial counts, and real-time polymerase chain reaction.

Results: Of the 36 rabbits used in this study, 3 animals in the CV group died within 72 hr of surgery. There was no difference in early mortality between P and V (0% vs. 0%; $P = 1.0$); however, early mortality was higher in the CV compared with the CP group (33% vs. 0%; $P = 0.023$). At 42 days, histologic evaluation of graft patency demonstrated no difference between P and V (67% vs. 33%; $P = 0.157$); however, patency was higher in CP than CV (56% vs. 12%; $P = 0.040$). In addition, no difference was found between the 2 contaminated groups in regard to the number of bacteria present on each graft material.

Conclusions: Permacol as an interposition graft is a feasible alternative to vein in a contaminated setting and shows resistance to infection in a rabbit model. Future studies are needed to evaluate this material in larger animal models.

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INTRODUCTION

Modern vascular trauma in civilian and military settings frequently involves penetrating mechanisms; from stab wounds to fragments from explosive devices, these injuries involve the extremities in 70–77%[1,2] and can result in significant segmental arterial loss.[3] Up to 50% of these injuries require interposition grafting or extra-anatomic bypass to restore blood flow.[4] Repair with autogenous vein graft is the gold standard for these repairs, particularly in contaminated wounds.[5] In the setting of multisystem injuries that result in significant hemodynamic instability or in blast injuries where significant soft tissue injuries destroy autogenous conduit, vein harvests can increase operative times in physiologically compromised patients. For these reasons, polytetrafluoroethylene (PTFE), a synthetic biologically inert material, is sometimes used as an alternative conduit. Early animal models show PTFE to be resistant to infection compared with vein,[5] but experience in humans has shown PTFE to be more susceptible to infections. Infections in PTFE after placement in contaminated vascular wounds have resulted in thrombosis and chronic infection requiring removal of the graft.[6] In addition, vein itself is shown to necrose and rupture in the setting of fulminant infection.[2,5,7–9] These complications necessitate search for an off-the-shelf product with material resistant to infection, reducing both operative times and associated morbidity of postgraft infections.

In a contaminated field, use of acellular dermal products has rates of surgical site infections comparable with wounds without synthetic or biosynthetic material. Notably, the property that causes biologic mesh to resist infection is a decreased inflammatory response due to its acellular structure. Decreasing the local inflammatory response may then cause progression through stages of healing as opposed to continued signaling of pathways that promote the cycle of inflammation brought about by a foreign body reaction.[10]

Permacol is a biologic acellular collagen matrix derived from porcine dermis. It is treated enzymatically to remove the cellular components and nonstructural proteins, thereby leaving native extracellular matrix. This product is also cross-linked with hexamethylene diisocyanate for added strength and durability. Permacol has been used to successfully repair soft tissue defects and hernias without cytotoxic, genotoxic, pyogenic, or hypersensitivity reactions.[11] In vascular surgery, Permacol was shown to be a comparable alternative to PTFE as a vascular patch in a rabbit model.[12] Furthermore, acellular biological materials have demonstrated resistance to bacterial colonization in both animal and human studies.[13–15]

Permacol has yet to be studied as a vascular conduit in a contaminated field. The objective of this study was to confirm the feasibility of Permacol as an alternative material for interposition grafting and to compare the utility of Permacol to vein as a conduit for arterial repair in the presence of bacterial contamination.

MATERIALS AND METHODS

This study and all methods were reviewed and approved by Dwight D. Eisenhower Army Medical Center's Animal Care and Use Committee and were performed in a facility accredited by the Association for the Assessment and Accreditation of Laboratory Animal Care, International. Research was conducted in compliance with the Animal Welfare Act and other federal statutes and regulations pertaining to animals and animal experimentation.

Male New Zealand white rabbits (Myrtles Rabbitry, Thompson Station, TN) weighing between 3.7 and 4.7 kg were used in this study. They were housed in an environmentally controlled room on a 12-hr light/dark cycle and were fed standard rabbit chow and water ad libitum. They were individually housed after surgery.

In the first experiment, 18 animals were randomized into interposition grafting of the common carotid artery with reversed external jugular vein (V; $n = 9$) or Permacol (Tissue Science Laboratories, Inc, Andover, MA) graft (P; $n = 9$). In the second experiment, an additional 18 animals were randomized as described previously. In this experiment, however, each graft was contaminated with *Staphylococcus aureus* (contaminated Permacol [CP] and contaminated vein [CV]).

Surgical Procedure

Animals underwent induction of anesthesia with an intramuscular injection of ketamine (35 mg/kg), xylazine (5 mg/kg), and glycopyrolate (0.1 mg/kg). General anesthesia was maintained with isoflurane (3.5%). The animals were continuously monitored with pulse oximetry. A longitudinal skin incision was made on the anterior border of the right cleidomastoid muscle. The strap muscles were identified and retracted laterally to expose the carotid sheath. The common carotid