Determination of Efficacy of New Hemostatic Dressings in a Model of Extremity Arterial Hemorrhage in Swine

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Abstract

Background: The HemCon (HC) bandage and QuickClot have been used over the past 6 years for treating external compressible hemorrhage in combat casualties. Previously, we tested three new hemostatic agents in granular/powder forms that were superior to these products. In this study, four new dressings (preselected) that are more suitable for battlefield application were evaluated. The efficacy and acute safety of the dressings were tested in our standard arterial hemorrhage model.

Methods: Anesthetized pigs (n = 38, 37 kg) were instrumented, and arterial blood was collected for hematological and coagulation assays. After splenectomy, the right femoral artery was isolated, injured (6 mm arteriotomy), and unrestricted bleeding allowed for 45 seconds. A hemostatic dressing (HC RTS [n = 6], Celox-D [CXb, n = 6], TraumaStat [TS, n = 10], Combat Gauze [CG, n = 10], or placebo gauze [PG, n = 6]) was then applied over the wound randomly and compressed for 2 minutes. Fluid resuscitation was administered and titrated to maintain a mean arterial pressure of 65 mm Hg. Animals were observed for 180 minutes or until death. Computed tomography angiography was performed on survivors and tissues were collected for histology.

Results: No differences were found in baseline blood measures, pretreatment blood loss or fluid infusion among groups. HCs and CXb testing discontinued after six unsuccessful tests, and the data were excluded. Stable hemostasis was achieved in two PG, two TS, and eight CG pigs in remaining groups resulting in stabilized mean arterial pressure and significantly different survival rates (20-80%, $p = 0.03$). CG secured hemostasis for 134.6 minutes ± 22.2 minutes, which was significantly longer than TS (35.7 ± 22.0 minutes, $p < 0.05$) but not different from PG (57.9 ± 36.2 minutes). The average survival time of CG-treated animals (167.3 ± 5.9 minutes) was also significantly longer ($p < 0.05$) than that of TS- (90.0 ± 15.3 minutes) or PG-treated (121 ± 19.3 minutes) pigs. Posttreatment blood loss was less in CG (37.4 ± 17.3 mL/kg) than that of the two other groups (TS = 79.8 ± 13.8 mL/kg and PG = 75.5 ± 23.8 mL/kg), but this difference was not significant. No significant rise in wound temperature (>1°C) was recorded after treatment with dressings and computed tomography images showed no flow through the vessels. Histologic observations showed mild to moderate changes in treated vessels with no difference between CG and PG. In vitro analysis of blood treated with CG or PG (lesser extent) showed increased clotting rate and clot strength. TS treatment had no effect on blood clotting activity.

Conclusion: CG was the most effective dressing tested in this arterial hemorrhage model. The hemostatic property of CG is attributed to its raw material (nonwoven Rayon and polyester blend), kaolin coating, and the large surface area (3 inch × 4 yd) of this absorbent sponge. CG is now recommended as the first line of treatment for life-threatening hemorrhage on the battlefield, replacing HC.