ABSTRACT
This study focused on a clinically relevant healthcare problem in the military: acute soft tissue wounds, or blisters. The trial was a prospective, controlled, randomized two-arm study evaluating the efficacy of a bioelectric dressing, Procellera®, applied topically two to three times per week for 2 weeks to blisters developed in Ranger trainees during training at Fort Benning, Georgia. A total of 80 US Army Ranger recruits with blister wounds below the knee were randomly assigned to one of two treatment groups (n = 40/group). The primary goal was to assess the clinical efficacy (rate of healing) of administered Procellera in conjunction with the standard-of-care (SOC) treatment, moleskin and Tegaderm®, on the healing rate of blisters compared with the SOC treatment alone. The secondary end points for efficacy were the quantities of wound fluid biomarkers and bacterial bioburden. The tertiary end point was assessment of pain in the treatment group compared with that of the control group during the 2-week study. The results showed no statistical difference between the SOC and SOC+Procellera groups in wound healing and pain. Wound fluid was reported for 24 participants (64.9%) in the SOC group and 21 participants (56.8%) in SOC+Procellera group at the baseline measurement (p = .475); however, the wounds were devoid of fluid on follow-up visits. The mild nature of the wounds in this study was apparent by the low pain scores at the beginning of the study, which disappeared by the follow-up visits. The average wound sizes were 2.2cm² and 1.5cm² for the SOC and SOC+Procellera groups, respectively. This trial protocol should be conducted on open soft-tissue wounds in severe heat. To our knowledge, this is the first clinical study conducted within the US Army Rangers training doctrine.

KEYWORDS: Procellera®; dressing, bioelectric; wound, acute; Rangers

Introduction
For Servicemembers with battlefield wounds, the speed and effectiveness of emergency treatment can mean the difference between life and death. Thousands of deployed Servicemembers are injured and disabled in the line of duty. Many of the wounds are sustained during contingency operations; others occur during noncombat duty training, and contribute to pain, quality-of-life impairment, and loss to duty. The need to improve the rapidity and quality of healing, and quality of life for active duty Servicemembers with acute wounds is of paramount importance to optimize mission readiness.

Dysregulated local and systemic inflammatory responses in acute wounds can lead to painful and resource-intense nonhealing wounds. A wound-treatment paradigm aimed at accelerating tissue repair, reduced pain, dysregulated inflammatory response, and bioburden precisely suits the unique requirements of our military health system. The potential benefits of a commercially available, noninvasive, minimal-risk treatment that can enhance wound healing and prevent wound infections cannot be underestimated.

A novel bioelectric dressing, Procellera® (Vomaris Innovations; http://vomaris.com), has shown promise in accelerating wound healing in trauma victims. Procellera is self-contained and wireless; no external power supply is required. The device is activated in the presence of a conductive fluid, which may come from wound exudate or exogenously administered fluid, such as normal saline. When activated, the presence of adjacent cells of silver and zinc spontaneously produces a sustained, predetermined magnitude of continuous current similar to the voltage level that occurs physiologically at areas of skin injury in normal hosts.

In field settings, particularly in basic training units, community hospital emergency rooms, battalion aid
stations, medical companies, and other deployed field operations, the bioelectric dressing may fulfill an unmet need for reducing bioburden,4–10 controlling local inflammation,11 mollifying pain,1 and advancing tissue repair in acute wounds.11–13 This advanced technology device has been cleared by the US Food and Drug Administration (FDA) and is a lightweight, self-contained, highly versatile wound dressing. It has a user-friendly design, can be self-administered, and requires minimal user training; thus, it is well suited for application to various wounds in an array of military environments. The bioelectric dressing has been used in the United States for various acute and chronic wound indications. A growing body of clinical data supports the safety of this device in treating soft-tissue wounds, burns, and inflammatory conditions.1–3,9–12 The primary goal of our study was to assess the clinical efficacy (measured as rate of healing) of Procellera administered in conjunction with the standard of care (SOC) treatment, Molleskin (Medical Action Industries) and Tegaderm® (3M; http://www.3m.com/), on the healing rate of blisters developed during training compared with the SOC in 80 Ranger recruits at Fort Benning, Georgia.

Methods

General Study Design
This was a prospective, randomized two-arm study evaluating the efficacy of Procellera applied topically two to three times per week for 2 weeks to blister wounds. Eighty Ranger recruits with blisters below the knee were randomly assigned to one of the two treatment groups (n = 40/group) immediately after completing the required 12-mile road march in 3 hours with a 60-pound rucksack. All subjects for this clinical study were recruited from the Ranger Training Course at Fort Benning.

The study was conducted according to the international standards of essential Good Clinical Practice and the International Conference on Harmonization, and to FDA standard regulations, Title 21 Code of Federal Regulations (CFR) Parts 11, 50, 54, and 56. In addition, applicable military regulations and procedures were followed and all study team members were trained on good clinical practice, human subject protection, and the Health Insurance Portability and Accountability Act. This clinical study was conducted in compliance with Dwight David Eisenhower Army Medical Center Institutional Review Board-approved protocol per 21 CFR 56 (FDA), 32 CFR 219 (Department of Defense), and Army Regulation 70-25.

Study Objectives
The primary goal of the study was to assess, over 2 weeks, the clinical efficacy of administered Procellera in conjunction with SOC compared with SOC alone in 80 subjects. Secondary end points for efficacy were the quantities of wound biomarkers (i.e., wound-fluid cytokines and chemokines) and bacterial bioburden (determined by culture and by quantitative reverse transcription polymerase chain reaction [qRTPCR] for bacterial 16S rRNA). The goal was assessment of pain in the treatment group compared with that of the control group during the 2-week study.

Device Description and Administration
According to Vomaris Innovations, “The Procellera bioelectric product [nonsignificant risk, FDA cleared] is a single layer dressing consisting of a polyester fabric layer impregnated with silver and zinc, which are held in position on the polyester with a biocompatible binder. The polyester fabric is single ply made of multifilament spun threads woven together” (Figure 1). Sustained microcurrents occur at the surface of the device in the presence of a conductive fluid such as wound exudate, normal saline, or hydrogel. Appropriate moistening agents for the dressings can be sterile water, sterile saline, water-based hydrogels, or wound exudate. The amount of moistening agent needs to be sufficient to moisten the entire dressing without excess running fluid. Procellera needs to be moist at all times for optimal results. If Procellera is dry, no current is present; however, the dressing still acts as an antimicrobial barrier to the wound.

Figure 1 Procellera is an antimicrobial wound dressing for partial- and full-thickness wounds. In the presence of a conductive fluid (i.e., saline, hydrogel, or wound exudate), the zinc and silver dot matrix creates low-level currents at the device surface.

Images were taken or adapted from http://procellera.com/.

For the experimental group in this study, the Procellera dressings were cut to a shape that extended beyond the edges of the study wound by approximately 1–2 cm. The dressings were then moistened with sterile saline-based hydrogel (product no. 91110; 3M) and placed over the wound with the dotted side directly contacting the surface of the wound. All bioelectric dressings were covered...
with moleskin, cut to shape that extended beyond the Procellera dressing edges approximately 1–2cm and secured in place with an occlusive dressing, Tegaderm. All Procellera dressings used for this study were purchased from Vomaris Innovations.

For the control group, the blister wounds were moistened with the same sterile saline-based hydrogel as the experimental group. Moleskin dressings (part no. 58634; Owens & Minor; https://www.medical-action.com/) were cut to shape that extended beyond the study wound edges approximately 1–2cm, and the dressings were covered and secured in place with Tegaderm.

For reference, the SOC treatment for Rangers recruits with blisters of the lower extremities includes wound cleansing with water and mild soap or saline, debridement (if necessary), application of moleskin, and, finally, covering with an occlusive dressing (e.g., Tegaderm).

**Clinical Trial Locations**
The clinical research portion of this study was conducted at Camp Rogers and Camp Darby in the confines of the Fort Benning, Georgia, military installation. The translational research portions of this study were conducted at the Henry M. Jackson Foundation Diagnostics and Translational Research Center in Gaithersburg, Maryland, and at Advanced Planimetric Services in Elmwood Park, New Jersey.

**Target Population and Randomization**
The target study population was recruits at Fort Benning, Georgia, who acquire blisters during their Ranger training. To provide a uniform wound type for the study, the type of acute injury was limited to blisters. Subjects were randomly assigned 1:1 to undergo acute wound management with either Procellera in conjunction with SOC (SOC+Procellera) or SOC alone. Once randomization occurred, subjects were considered enrolled in the study and, thereafter, were informed as to study assignment. Randomization was balanced between the two treatment arms.

**Wound Healing Evaluation**
Wound healing evaluations were performed by a medic/physician extender upon study initiation (day 0), and on days 4 (±3 days), 7 (±3 days), 10 (±3 days), and 14 (±3 days), the final study visit according to standard clinical protocol. Digital photographs (Canon PowerShot ELPH 115 IS; https://www.usa.canon.com) of the target wound were taken at each visit; a ruler labeled with participant number and date was visible in each photograph. Photographs were scanned and quantified with computerized digital image planimetry (PictZar Calibrated Digital Measurement; Advanced Planimetric Services; http://advanced-planimetric-services-llc.software.informer.com/) to determine the wound surface area and percent of healing. At each measurement point, wound status was characterized by length, width, surface area, circumference, pain, and presence of wound fluid. Percentage of healing was calculated at each wound measurement after the baseline assessment (day 0). All image analysis was conducted independently by Dr. Marty Wendelken, an expert in analyzing wound images who was unaware of the subject’s group assignment.

**Bioburden and Cytokine Analysis**
Sequential wound-fluid samples were to be obtained from the blisters during each clinical visit. During the 2-week clinical trial, wound fluid was collected at study initiation (day 0) and, if feasible, on the study dates listed above. If a fluid-filled vesicle was present, the blister was punctured with a sterile needle to allow fluid to drain. The wound fluid was collected in the sterile syringe and then placed in a sterile vial. The vial with the fluid was transferred to the laboratory for processing. This collection schedule permitted the comparison of sequential bioburden and cytokine, chemokine, and/or growth factor levels in wounds for each individual subject.

**Sample Processing for Colony-Count Determination**
Samples of glycerol-cryopreserved wound fluid were analyzed for bacterial bioburden. These fluids were diluted serially, plated on trypticase soy and chocolate agar plates, and incubated for 24–48 hours at 37°C for quantitative bacteriology.

**Sample Processing for Quantitative PCR**
The wound fluid pellets, preserved in RNAlater® (catalog no. AM7020; Thermo Fisher Scientific; https://www.thermofisher.com), were extracted for the genomic material, using a commercially available extraction kit. Universal primers for 16S ribosomal ribonucleic acid (rRNA) gene were used in qRT-PCR experiments to determine the bacterial burden of the sample based on the copy number of 16S rRNA genes.

**Pain Profile Assessment Using the Numeric Pain Intensity Scale**
Wound-related pain was assessed during the trial via the Numeric Pain Intensity Scale. The pain scale is a standardized 11-point (0–10) Likert pain scale, with 0 representing no pain and 10 representing the patient’s worst imaginable pain. Mean subject-reported Numeric Pain Intensity Scale values over time were statistically analyzed to assess differences across treatment group and time.

**Data Collection and Analysis**
The Henry M. Jackson Foundation served as the data-coordinating center for data management, regulatory,
and site-monitoring support for the study team. Clinical data management was performed in accordance with applicable clinical trial site institutional review board-specified requirements. The original case report forms were retained by the site principal investigator and the Henry M. Jackson Foundation. All data specific to this study were collected, recorded on case report forms, and entered in a secure, password-protected computerized database by the Henry M. Jackson Foundation. Statistical analysis was conducted by an independent statistician. The statistician was blinded to group membership (the groups were coded Group A and Group B).

**Clinical Data Analysis**

Data were entered into an Excel spreadsheet and verified against clinical report forms. Means (± standard deviation) are reported for descriptive continuous data, and counts (given as percentages) for categorical data. Means (± standard error) are reported for linear models. Independent-sample t tests and Fisher exact tests were used to assess differences between groups at baseline. A mixed-model linear analysis approach, with an unstructured repeated covariance matrix and random effects for participants, was used to test for differences between groups over time. Kaplan-Meier analyses and log-rank tests were conducted to evaluate difference between groups on time to 100% wound healing. An α of .05, two-tailed, defined statistical significance for all tests. Data were analyzed using SPSS version 22 (IBM; http://www.ibm.com/). Analyses are reported for both the intent-to-treat data set and a limited “on-protocol” data set due to the loss of data for several participants in both groups.

This study was powered to address the primary hypothesis that the bioelectric dressing would accelerate wound healing and reduce wound-healing time when compared with the SOC treatment. Based on a small-to-moderate effect size (Cohen’s f = 0.20), a mixed-linear model, with random effects for participants was expected to yield 80% power to detect an interaction between group and time for percent healing from baseline if 40 participants per group were enrolled, allowing for a 10% dropout rate.

**Results**

**Participants**

Baseline wound measurements were taken on 76 of the 80 participants enrolled in the study. One participant in the SOC group and one in the SOC+Procellera group were determined to be ineligible after enrollment. One participant in the SOC+Procellera group was discontinued from the study because of a blood blister. Another wound of a participant assigned to the SOC group was photographed, but the photograph could not be located, making changes in wound size from baseline incalculable. Two participants had only a baseline measurement taken: one in the SOC group and one in SOC+Procellera group. Both participants were dropped from the Ranger school and neither had healed completely on termination. Five participants had only one follow-up measurement—three from the SOC group (two adverse reactions to Tegaderm and one dropped from the Ranger school) and two from the SOC+Procellera (both dropped from the Ranger school). None had healed completely on termination. One participant in the SOC group missed follow-up visit 1, and three participants (two in the SOC group and one in the SOC+Procellera group) missed follow-up visit 2. All healed completely by study’s end. One additional participant (SOC+Procellera group) was photographed at follow-up visit 3, but the photograph could not be evaluated. This subject had not healed completely. For one participant assigned to the SOC+Procellera group, a nonindex blister was treated on follow-up visit 1. Table 1 summarizes the reasons for these participants’ exclusion.

<table>
<thead>
<tr>
<th>Reason for Exclusion</th>
<th>SOC, No.</th>
<th>SOC+Procellera, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No baseline measurement</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Only baseline measurement</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Only one follow-up measurement</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Missed at least one follow-up measurement</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Wrong blister treated</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

SOC, standard of care; SOC+Procellera, standard of care plus Procellera.

Participants whose wounds received no follow-up measurements were excluded from further analysis, leaving 37 participants in each group. This subset of participants composed the intent-to-treat group. Another subset of participants, the “on-protocol” group, was made up of participants who attended all follow-up visits or all visits until complete healing had occurred. The participant for whom the nonindex blister was treated was excluded from this group. The on-protocol subgroup included 27 participants (67.5% of those enrolled) assigned to the SOC group and 32 participants (80% of those enrolled) assigned to the SOC+Procellera group. All analyses were repeated for this subset. A best estimate of the efficacy of Procellera should fall somewhere within the window provided by results for the intent-to-treat and the on-protocol analyses.

In the intent-to-treat data set, the two groups were well balanced across baseline measures; none of the
differences was statistically significant. In the on-protocol subset, the wounds for the SOC group were somewhat larger, on average, and they more frequently had fluid present than those of participants assigned to the SOC+Procellera treatment; however, again, none of the differences across groups was statistically significant.

**Analysis of Healing Rate**

Percent change in wound area from baseline measurement was calculated to estimate participants’ healing rate (Table 2). Mean percent changes for the intent-to-treat and on-protocol data sets are shown in Figure 2. Among those followed completely (i.e., on-protocol group), by follow-up visit 3, one participant in the SOC group (3.7%) and two participants in the SOC+Procellera group (6.25%) had failed to heal 100% ($p = .66$). The assessment of difference in area of the wound across measurement periods was performed using a mixed-model linear analysis approach, with an unstructured repeated covariance matrix and random effects for participants. The interaction term (group × visit) was of particular interest because a significant interaction would indicate differential healing rates across groups. Means, standard errors, and 95% confidence intervals are provided in Table 3. The interaction term was not significant ($p = .679$). The main effect for visit was significant ($p < .001$), but the main effect for group was not ($p = .697$).

The wound area data were somewhat skewed, so a log scale was applied to normalize the distributions. The analysis was repeated using the logged data. The interaction term, again, was not significant ($p = .509$). The main effect for visit was significant ($p < .001$), but the main effect for group was not ($p = .970$). These analyses were repeated using the on-protocol data set. Means, standard errors, and 95% confidence intervals for this data set are provided in Table 4. The interaction term was not significant ($p = .353$). The main effect for visit was significant ($p < .001$), but the main effect for group was not ($p = .494$).

### Analysis of 100% Healing: Intent-to-Treat and On-Protocol Groups

In the intent-to-treat analysis, 30 of 37 participants (81.1%) in the SOC group and 32 of 37 (86.5%) in the SOC+Procellera group healed completely during the trial ($p = .528$; Figure 3). In the on-protocol analysis, 26 of 27 participants (96.3%) in the SOC group and 30 of 32 (93.8%) in the SOC+Procellera group healed completely during the trial ($p = .657$; Figure 3).

### Time-to-Event Analysis: Intent-to-Treat and On-Protocol Groups

Kaplan-Meier analyses were conducted using both the intent-to-treat and on-protocol data sets. The day on

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**Table 2** Baseline Characteristics for SOC and SOC+Procellera Intent-to-Treat and On-Protocol Data Sets

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intent-to-Treat Data Set</th>
<th>On-Protocol Data Set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOC ($n = 36$)*</td>
<td>SOC ($n = 27$)</td>
</tr>
<tr>
<td>Area, mean (SD), cm²</td>
<td>1.92 (3.08)</td>
<td>2.27 (3.49)</td>
</tr>
<tr>
<td>Length, mean (SD), cm</td>
<td>1.43 (1.01)</td>
<td>1.63 (1.10)</td>
</tr>
<tr>
<td>Width, mean (SD), cm</td>
<td>1.31 (0.79)</td>
<td>1.32 (0.81)</td>
</tr>
<tr>
<td>Circumference, mean (SD), cm</td>
<td>4.74 (2.78)</td>
<td>5.06 (3.06)</td>
</tr>
<tr>
<td>Pretreatment Numeric Pain Intensity Scale score, mean (SD)</td>
<td>3.24 (2.31)</td>
<td>3.48 (2.41)</td>
</tr>
<tr>
<td>Wound fluid present (no., %)</td>
<td>24 (64.9)</td>
<td>18 (66.7)</td>
</tr>
</tbody>
</table>

SOC, standard of care; SOC+Procellera, standard of care plus Procellera.

*Baseline photograph missing for subject 39.
which the wound was determined to have healed 100% was defined as the end point. In the intent-to-treat data set, 30 of 37 participants (81.1%) in the SOC group and 32 of 37 (86.5%) in the SOC+Procellera group reached the end point. The time-to-event curve is shown in Figure 4. Associated data for the log-rank test are provided in Table 4. The SOC group appeared to have achieved 100% healing at a slightly faster rate than the SOC+Procellera group, but the difference was not significant ($p = .68$).

In the on-protocol data set, 26 of 27 participants (96.3%) in the SOC group and 30 of 32 (93.8%) in the SOC+Procellera group reached the end point. The time-to-event curve for the on-protocol analysis is displayed in Figure 5. Associated data for the log-rank test are also provided in Table 4. The SOC group appeared to have achieved 100% healing at a slightly faster rate than the SOC+Procellera group; however, the difference was not statistically significant ($p = .518$).

### Table 3 Intent-to-Treat and On-Protocol Data Sets (Mean [SE]) for SOC and SOC+Procellera Groups Across Measurement Periods

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit</th>
<th>Intent-to-Treat Group</th>
<th></th>
<th>On-Protocol Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean (SE)</td>
<td>95% CI</td>
<td>Mean (SE)</td>
<td>95% CI</td>
</tr>
<tr>
<td>SOC</td>
<td>Baseline</td>
<td>2.01 (0.47)</td>
<td>1.082 to 2.935</td>
<td>2.27 (0.48)</td>
<td>1.317 to 3.224</td>
</tr>
<tr>
<td></td>
<td>Follow-up 1</td>
<td>1.60 (0.37)</td>
<td>0.851 to 2.338</td>
<td>1.69 (0.38)</td>
<td>0.924 to 2.461</td>
</tr>
<tr>
<td></td>
<td>Follow-up 2</td>
<td>0.46 (0.25)</td>
<td>-0.031 to 0.959</td>
<td>0.47 (0.27)</td>
<td>-0.08 to 1.025</td>
</tr>
<tr>
<td></td>
<td>Follow-up 3</td>
<td>0.11 (0.09)</td>
<td>-0.077 to 0.295</td>
<td>0.11 (0.11)</td>
<td>-0.1 to 0.324</td>
</tr>
<tr>
<td>SOC+Procellera</td>
<td>Baseline</td>
<td>1.66 (0.46)</td>
<td>0.735 to 2.582</td>
<td>1.27 (0.44)</td>
<td>0.393 to 2.145</td>
</tr>
<tr>
<td></td>
<td>Follow-up 1</td>
<td>1.21 (0.37)</td>
<td>0.468 to 1.95</td>
<td>0.89 (0.35)</td>
<td>0.187 to 1.599</td>
</tr>
<tr>
<td></td>
<td>Follow-up 2</td>
<td>0.69 (0.24)</td>
<td>0.224 to 1.164</td>
<td>0.65 (0.25)</td>
<td>0.14 to 1.154</td>
</tr>
<tr>
<td></td>
<td>Follow-up 3</td>
<td>0.11 (0.09)</td>
<td>-0.073 to 0.284</td>
<td>0.09 (0.10)</td>
<td>-0.1 to 0.289</td>
</tr>
</tbody>
</table>

CI, confidence interval; SE, standard error; SOC, standard of care; SOC+Procellera, standard of care plus Procellera.

### Table 4 Estimated Days to Heal 100% for SOC and SOC+Procellera Intent-to-Treat and On-Protocol Data Sets

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Estimated No. of Days to Heal (Mean)</th>
<th>LCL (95% CI)</th>
<th>UCL (95% CI)</th>
<th>Estimated No. of Days to Heal (Median)</th>
<th>LCL (95% CI)</th>
<th>UCL (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent-to-treat data set</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (n = 37)</td>
<td>8.90</td>
<td>7.37</td>
<td>10.43</td>
<td>9.0</td>
<td>6.68</td>
<td>11.32</td>
</tr>
<tr>
<td>B (n = 36)</td>
<td>9.36</td>
<td>7.86</td>
<td>10.86</td>
<td>9.0</td>
<td>7.25</td>
<td>10.75</td>
</tr>
<tr>
<td>Log-rank test, $p = .680$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On-protocol data set

| A (n = 30)       | 7.82                                 | 6.08        | 9.55       | 8.0                                    | 3.83        | 12.17       |
| B (n = 33)       | 8.69                                 | 7.09        | 10.28      | 8.0                                    | 6.90        | 9.10        |
| Log-rank test, $p = .518$ |                                      |             |             |                                        |             |             |

CI, confidence interval; LCL, lower control limit; SOC, standard of care; SOC+Procellera, standard of care plus Procellera; UCL, upper control limit.

**Figure 3** Cumulative accounting of 100% healing across the three follow-up visits for SOC and SOC+Procellera for intent-to-treat and on-protocol data sets, including those participants not healed.

Pain

Mean pain scores for both pretreatment and posttreatment were calculated for the SOC and SOC+Procellera groups across all visits. Pretreatment scores for the
Wound Fluid

Wound fluid was reported for 24 participants (64.9%) in the SOC group and 21 participants (56.8%) in the SOC+Procellera group at the baseline measurement ($p = .475$). Thereafter, fluid was present in only one participant (in the SOC+Procellera group) at follow-up visit 1, but this resolved by follow-up visit 2.

Bioburden Analysis

Blister fluids were collected from 38 blisters at baseline. They were preserved in glycerol and samples were stored frozen until assays were performed. No blister fluids were collected during the follow-up visits because the blisters were in a healing process and excessive fluid volumes were not present. Of the 38 blister-fluid samples tested, viable bacteria were isolated from nine. Table 5 lists bacterial species isolated from the blister-fluid samples that showed growth on bacterial media. The species of organisms were identified by using the Phoenix automated instrument (BD; http://www.bd.com), which allows identification at the species and genus level. All the isolate bacterial species were classified as facultative anaerobes except for sample GOR003, which was an obligate aerobe and saprophytic. Table 6 lists all tested samples.

Sufficient blister-fluid volumes were collected from nine blisters to allow for pelleting the blister fluid by centrifugation and treating the pellet with RNA later. An RT-PCR analysis was conducted for the presence of 16S rRNA specific for bacteria. A standard RNA at a 10-fold dilution (from 1ng to 1fg) was used as a reference for the RT-PCR analysis. When the assays were conducted, it was noted that there were significant variations in the total RNA isolated from each specimen. All samples were processed in duplicate and diluted 1:10 before loading them for the RT-PCR assays. The standard curve is available but not shown. A cutoff (27.45 Ct of RT-PCR amplification) was determined according to the crossing-point values of the negative control. All unknown RNA samples with crossing-point values (the average of duplicate samples) under the cutoff were considered positive for amplification. It is interesting to
note that viable bacteria were not isolated or identified from any of the samples assayed using RT-PCR methodology (i.e., standard curve). The RT-PCR data suggest the presence of nonculturable bacteria at a low level.

Blister fluid from subjects 30 and 32 were positive for amplification, indicating the possible presence of an unidentified bioburden (Table 6). The blisters on these two subjects had not healed when the results of their last clinical visits were recorded at the end of week 2. This study did not allow for collection of fluids from the subjects during the study. The RT-PCR data are significant for these two subjects and provides impetus for designing new studies to determine the relevance nonhealing and possible presence of nonculturable organisms.

Discussion

Silver is an active component of many wound dressings used in clinical practice. Studies conducted throughout the 1970s demonstrated the potency of silver ions used with anodic microcurrents as an antimicrobial, bactericidal, and fungicidal agent.\textsuperscript{14-16} In 1978, Becker and Spadaro showed the effect of a continuous 0.9V direct microcurrent applied to an open orthopedic wound.\textsuperscript{17} They used electrically generated silver ions as a method of infection control.\textsuperscript{18}

Zinc has been used for decades to treat wounds and is a required cofactor in many of the wound healing reactions, including cellular DNA polymerase, reverse transcriptase, and the action of tissue growth factors. Zinc potentiates the breakdown and formation of collagen, and is a vital cofactor in multiple secondary cellular messenger systems, which include cytokines, chemokines, and tissue proteases—key modulators of inflammation and cellular function. This element has been shown to stimulate epidermal cellular division, increase vascular endothelial repair, and increase metalloproteinases, all positive influences in the biology of wound healing.\textsuperscript{19}

### Table 5 Bacterial Species Isolated From Blister Fluids at Baseline Treatment

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Sample ID No.</th>
<th>Species Identified</th>
<th>Blister Treatment</th>
<th>F/U Visit No. for Evaluation of 100% Healing</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR0003-BL-WB1</td>
<td>4560019</td>
<td>Micrococcus luteus</td>
<td>SOC</td>
<td>3</td>
</tr>
<tr>
<td>GOR0009-BL-WB1</td>
<td>4560067</td>
<td>Staphylococcus warneri</td>
<td>Procellera</td>
<td>3</td>
</tr>
<tr>
<td>GOR0016-BL-WB1</td>
<td>4560123</td>
<td>S. warneri</td>
<td>SOC</td>
<td>3</td>
</tr>
<tr>
<td>GOR0025-BL-WB1</td>
<td>4560195</td>
<td>S. haemolyticus</td>
<td>SOC</td>
<td>2</td>
</tr>
<tr>
<td>GOR0044-BL-WB1</td>
<td>4560347</td>
<td>S. warneri, S. hominis</td>
<td>SOC</td>
<td>Not healed at F/U 1; dropped from study at this visit</td>
</tr>
<tr>
<td>GOR0048-BL-WB1</td>
<td>4560379</td>
<td>S. epidermidis</td>
<td>SOC</td>
<td>3</td>
</tr>
<tr>
<td>GOR0054-BL-WB1</td>
<td>4560427</td>
<td>S. epidermidis</td>
<td>SOC</td>
<td>1</td>
</tr>
<tr>
<td>GOR0061-BL-WB1</td>
<td>4560484</td>
<td>S. epidermidis</td>
<td>Procellera</td>
<td>2</td>
</tr>
<tr>
<td>GOR0062-BL-WB1</td>
<td>4560491</td>
<td>S. epidermidis</td>
<td>SOC</td>
<td>Not healed at F/U 1; dropped from study at this visit</td>
</tr>
</tbody>
</table>

F/U, follow-up; ID, identification; SOC, standard of care for blisters (i.e., control group).

### Table 6 Test of Blister Fluid Pellet Preserved in RNA later for 16S Bacterial Bioburden, Using RT-PCR Analysis

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Sample ID No.</th>
<th>Total RNA, ng</th>
<th>RNA Load, ng</th>
<th>RT-PCR CP, Ct</th>
<th>Blister Treatment</th>
<th>Blister Healed, Yes/No; F/U Visit No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOR0030-BL-WL1</td>
<td>4560238</td>
<td>354</td>
<td>0.885</td>
<td>25.1</td>
<td>SOC</td>
<td>No; 3</td>
</tr>
<tr>
<td>GOR0032-BL-WL1</td>
<td>4560255</td>
<td>ND</td>
<td>ND</td>
<td>24.52</td>
<td>Procellera</td>
<td>No; 3</td>
</tr>
<tr>
<td>GOR0033-BL-WL1</td>
<td>4560263</td>
<td>540</td>
<td>1.351</td>
<td>24.35</td>
<td>Procellera</td>
<td>Yes; 3</td>
</tr>
<tr>
<td>GOR0036-BL-WL1</td>
<td>4560287</td>
<td>4.8</td>
<td>0.12</td>
<td>22.12</td>
<td>Procellera</td>
<td>Yes; 2</td>
</tr>
<tr>
<td>GOR0040-BL-WL1</td>
<td>4560319</td>
<td>418</td>
<td>1.044</td>
<td>20.78</td>
<td>SOC</td>
<td>No; 1</td>
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<tr>
<td>GOR0046-BL-WL1</td>
<td>4560367</td>
<td>25.6</td>
<td>0.64</td>
<td>20.44</td>
<td>SOC</td>
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</tr>
<tr>
<td>GOR0053-BL-WL1</td>
<td>4560423</td>
<td>1,811</td>
<td>4.527</td>
<td>20.75</td>
<td>Procellera</td>
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<tr>
<td>GOR0053-BL-WL2</td>
<td>4560424</td>
<td>1,130</td>
<td>2.862</td>
<td>21.15</td>
<td>Procellera</td>
<td>Duplicate</td>
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<tr>
<td>GOR0056-BL-WL1</td>
<td>4560447</td>
<td>616</td>
<td>1.539</td>
<td>19.97</td>
<td>SOC</td>
<td>Yes; 3 (missed F/U 2)</td>
</tr>
</tbody>
</table>

CP, crossing point; F/U, follow-up; ID, identification; ND, not detectable; SOC, standard of care for blisters (i.e., control group).
Procellera is an advanced wound care bandage consisting of woven absorbent polyester containing both elemental silver (0.9mg/cm²) and zinc (0.3mg/cm²), and it provides an effective barrier to microbial penetration for partial- and full-thickness wounds. The device has a biologically inspired design: the flexible membrane creates an electrical potential of approximately 1V in the presence of fluid, the same approximate electrical potential that occurs when the skin is injured or broken. The product is an FDA-cleared bioelectrical dressing with the following indications for use: partial- and full-thickness wounds, such as pressure ulcers, venous ulcers, diabetic ulcers, burns, surgical incisions, and donor and/or recipient graft sites. Procellera has been used in the United States for various acute and chronic wound indications, and a growing body of preclinical and clinical data supports the efficacy of this device in treating soft-tissue wounds, burns, and inflammatory conditions.1-3,9-13

The primary goal of this study was to assess the clinical efficacy of Procellera administered in conjunction with SOC to treat blister wounds in Ranger recruits. The results of the trial showed that there was no statistical difference between the SOC and the SOC+Procellera groups in wound healing and pain. Wound fluid was reported for 24 participants (64.9%) in the SOC group and 21 participants (56.8%) in the SOC+Procellera group at the baseline measurement (p = .475). Thereafter, fluid was present in only one participant (in the SOC+Procellera group) at follow-up visit 1, but this resolved by follow-up visit 2. Therefore, because of lack of blister fluid during follow-up visits, we were not able to conduct statistical analysis for wound bioburden and cytokines. The mild nature of the wounds in this study was apparent by the low pain scores at the beginning of the study, which indicated no pain by the follow-up visits. Overall, the wound sizes were small (mean, 2.2cm² and 1.5cm² for the SOC and SOC+Procellera groups, respectively).

One of the main inclusion criteria for this study was that the wounds (blisters) be covered with skin tissue. The selection of patients with small, skin-covered wounds was probably not appropriate for the clinical efficacy evaluation of Procellera compared with SOC for blister wounds. In addition, the study was conducted during the relatively dry and cold time of the year (October through March) in Georgia, and, to our knowledge, there are no data on blister types developed under other weather conditions, including extreme heat. Rangers with larger open wounds (which typically result from the extreme heat) would possibly have been a more appropriate patient population to assess healing, pain, and bacterial presence. According to our results, the use of Procellera may not be an ideal treatment for closed friction small blisters. The current SOC treatment, mole-skin, should remain the first line of defense for friction blisters in US Army Rangers. Procellera is a novel, and the only FDA-approved, wireless, electroceutical, antibacterial wound-care technology; therefore, future efficacy studies for battlefield-related wounds (e.g., open acute wounds) are well warranted.

Acknowledgments
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GOALS

1. Accomplish the mission with minimal casualties.
2. Maintain tactical superiority.
3. Expect to keep the canine (K9) team (handler and/or K9) maximally engaged in neutralizing the existing threat (e.g., active shooter, structural collapse, confined space, hazardous materials).
4. Maintain team safety by ensuring, when feasible, that the K9 handler is always involved when handling an injured K9.
5. Move the downed K9 team to a safe position and prevent any human or K9 casualty from sustaining additional injuries.
6. Treat immediately life-threatening hemorrhage.
7. Minimize public harm.

Principles

1. The term Operational K9 (OpK9) refers to the distinct subpopulation of elite civilian working K9s that operate in high-threat or tactical environments. Examples include K9s that serve federal and local law enforcement (LE) and force protection agencies (e.g., police, Transportation Security Administration, Federal Bureau of Investigation, Bureau of Alcohol, Firearms, Tobacco, and Explosives, US Marshals Service, US Customs and Border Protection), and search-and-rescue groups (e.g., Federal Emergency Management Agency Urban Search and Rescue, various Sheriff's County search-and-rescue K9 teams).
2. Establish and maintain tactical control and defer in-depth medical interventions if engaged in ongoing direct threat (e.g., active fire fight, structural collapse, dynamic postexplosive scenario).
3. Threat mitigation techniques will minimize risk to casualties and the providers. These should include techniques and tools for rapid casualty access and egress.

a. It is highly recommended that OpK9s operating in a tactical environment wear a body-type harness to assist in rapid extraction/extrication from the hot zone.

b. K9 handling and restraint

i. Any injured or stressed K9 is considered unpredictable and may bite, even its own handler.

ii. Consider applying a muzzle prior to handling a conscious K9 when no contraindications to muzzling exist (e.g., upper airway obstruction, respiratory complications, severe facial trauma, heat-related injuries, vomiting, coma-tose state).

iii. Handlers should carry a quick application type of muzzle in a known, easily accessible location for expedient handler/team use when and if needed.

c. It is strongly urged to have at least two alternate team members or designated first responders (e.g., emergency medical services [EMS], fire departments) trained in basic K9 handling techniques for situations when the handler is down.

i. When feasible, these personnel should have a well-established and positive rapport with OpK9s they support.

ii. It is recommended that only select members are granted this level of rapport to prevent decreasing the reliability of the K9 asset.

d. Threat mitigation to rescuer and casualty ALWAYS takes priority.

i. DO NOT delay extraction time to a safe zone for the sole purpose of applying a muzzle on an injured K9.

ii. Handler/responder must weigh the benefits and risks of muzzling the K9 based upon the likelihood of a re-emerging threat.

iii. Consider that in situations where a threat re-appears, a muzzled K9 will no longer be able...
K9 Tactical Emergency Casualty Care (TECC): DTC Hot Zone Guidelines

1. Mitigate any threat (e.g., return fire, use less lethal technology, assume an overwhelming force posture, extraction from immediate structural collapse or fire, stop the burning process) and move to a safer position.

2. Keep the K9 casualty or K9 team engaged in any tactical operation, if appropriate and until threat is neutralized.

3. K9 casualty extraction: The handler/responder should secure and extract an injured K9 from the hot zone to a safe location in a way that does not further jeopardize human life (self or team):
   a. Avoid exposing themselves or other team members to an imminent threat for the sole reason of extracting an injured OpK9.
   b. Engage and neutralize the threat or ensure the active threat is neutralized before rendering aid or extracting the OpK9 casualty.
   c. When the handler/responder is already behind cover and separated from an injured K9, they should remain under cover and attempt to call and direct the K9 to their location, because some injured OpK9s may remain ambulatory.

   a. When the K9 handler is injured and team members and/or responders are not close to assist, then the handler (if possible) should:
      i. Engage the threat and immediately apply self-aid when feasible.
      ii. If hostile threat is neutralized, secure the OpK9 by any quick, expedient method. A loose, agressive, or anxious K9 may be a threat to rescuers and prevent extraction or provision of medical aid to the downed handler.
   b. If the K9 team is down and unresponsive, or is responsive but cannot move, the scene commander or team leader should weigh the risks and benefits of a rescue attempt in terms of manpower, likelihood of success, and mission sustainment.
      i. Consider remote medical assessment techniques.
      ii. Recognize that threats are dynamic and may be ongoing, requiring continuous threat assessments.

5. Stop life-threatening external hemorrhage, if tactically feasible.
   a. Remember, the primary goal during DTC is to quickly remove the K9 casualty and handler/rescuer away from the direct imminent threat (e.g., “Get off the X”).
      i. Consider moving the K9 casualty to safety (behind cover) before applying direct pressure or a tourniquet (TQ) if the situation allows.
   b. Direct pressure
      i. Remains the primary tenet of controlling external hemorrhage in K9s under DTC.
   c. Wound packing and hemostatic agents
      i. Often not tactically feasible to perform appropriately under DTC
      ii. May consider loosely packing (i.e., wadding or stuffing) dressing into the wound and then securing with a quick application pressure wrap as situation permits.
   d. Tourniquets:
      i. Not considered first-line treatment for controlling extremity hemorrhage in K9s because most human commercial, windlass TQs (e.g., Combat Application Tourniquet® [Composite Resources Inc.; http://combatourniquet.com/], SOF® Tactical Tourniquet [Tactical Medical Solutions; https://www.tacmedsolutions.com/product/sof-tactical-tourniquet-wide/]) do not work effectively on K9 extremities.
      ii. Consider TQ application in K9s under the following conditions:
         c. Extremity hemorrhage appears life threatening (e.g., K9 has suffered a complete traumatic limb or tail amputation), AND
         d. Bleeding remains refractory to other methods of hemostasis (e.g., direct pressure, pressure dressing), AND
(e) The anatomic site is amenable to TQ application (i.e., mainly limbs and tail wounds).

iii. When a TQ is warranted (e.g., under Section 4.d.ii.), consider applying an ITQ or wide, elastic, nonwindlass TQ (e.g., SWAT-T® [TEMS Solutions; http://www.swattourniquet.com/])

(a) ITQs may be constructed from material such as a cravat, long-sleeved shirt, or back pack strap (at least 3.8cm or 1.5 inches wide).

(b) A stick, small metal bar, or even a long-bladed knife firmly seated in its sheath may be used as the torsion (i.e., windlass) device.

iv. Apply the ITQ as proximal (i.e., high on the limb or tail) as possible or at least 2–3 inches above the wound.

v. DO NOT apply ITQ directly over a joint or wound.

vi. Tighten until cessation of bleeding AND loss of palpable distal pulses. Optimal use of limb TQs must result in both

(a) Cessation of bleeding, AND

(b) Loss of distal pulses in the extremity.

vii. Expose and clearly mark all TQ sites with an indelible marker.

(a) Indicate date and time of application.

(b) Do not cover a TQ.

e. Immobilize and elevate the area when practical and feasible. Keep the K9 as calm as possible to avoid inadvertent elevations in arterial blood pressure.

f. Consider quickly placing the K9 casualty in position to protect airway, if tactically feasible.

Principles

1. Maintain tactical control and complete the overall mission.

2. As applicable, ensure safety of first responders and K9 casualties by always:

   a. Keeping the K9 handler involved when handling or treating an injured K9.

   b. Considering muzzling the K9 when no contraindications to applying muzzle exist (e.g., respiratory complications, heat-related injuries, vomiting, comatose state) and if not performed during DTC.

   c. Considering early use of chemical restraint for injured K9s that are fractious and potentially aggressive because of pain, stress, and/or fear.

   d. Training medical providers with the likelihood for treating injured K9s in safe K9 handling techniques.

3. Conduct dedicated patient assessment and initiate appropriate life-saving interventions as outlined in the following ITC guidelines.

4. DO NOT DELAY casualty extraction/evacuation for non-lifesaving interventions.

5. Consider establishing a casualty collection point if multiple casualties are encountered.

6. Unless in a fixed casualty collection point, triage in this phase of care should be limited to the following categories:

   a. Uninjured

   b. Deceased/expectant

   c. All others

7. Establish communication with the tactical and/or command element and request or verify initiation of casualty extraction/evacuation.

8. Prepare casualties for extraction and document care rendered for continuity-of-care purposes.

K9 ITC Warm Zone Guidelines

1. Restraint. Properly restrain K9 per guidelines described under DTC.

   a. Consider the K9’s mouth and teeth as equivalent to an LE officer’s weapon and, therefore, it should be made safe if the K9 is injured and/or the K9 has an altered mental status.

   b. Secure once the threat is neutralized.

   c. Consider early use of chemical restraint for injured K9s that are fractious and potentially aggressive because of pain, stress, and/or fear.

      i. Follow local veterinary-approved protocols or refer to in the K9 TECC Supplement (http://www.k9tecc.org/resources.html) for chemical-restraint protocols.

2. Bleeding. Reassess for massive hemorrhage.

   a. Reassess interventions applied for massive hemorrhage performed during DTC.

   b. Assess for and control any other unrecognized sources of major hemorrhage.
c. Direct pressure:
   i. If not already done, apply direct pressure and pressure dressing with deep-wound packing to control life-threatening external hemorrhage.

d. Wound packing:
   i. Consider controlling junctional hemorrhage (inguinal or axillary) or other deep, compressible hemorrhaging wounds if the bleeding site is not controlled by direct pressure application alone.
      (a) Performed for major junctional hemorrhage and upper extremity wounds above the elbow and stifle (i.e., triceps, caudal thigh)
      (b) Not very effective or necessary on most K9 distal limb wounds (i.e., below elbow and knee/stifle) because of lack of significant musculature
   ii. Impregnated hemostatic dressing or standard roll gauze may be used for wound packing.
      (a) Topical hemostatic agents are to be applied in the form of an impregnated gauze dressing. Apply in accordance with manufacturer’s guidelines.
      (b) DO NOT apply powdered or granular forms of hemostatic agents directly to the wound.
   iii. Refer to K9 TECC Supplement or local veterinary-approved protocols for guidance on deep-wound packing for K9s (e.g., types of material, wound packing protocol).

e. Tourniquet:
   i. Reassess all TQs that were applied during previous phases of care by exposing the injury and determining if a TQ is needed.
   ii. TQs applied hastily during DTC phase that are determined to be both necessary and effective in controlling hemorrhage should remain in place if the casualty can be rapidly evacuated to definitive veterinary care.
   iii. Consider conversion to pressure or hemostatic dressing and bandage if:
      (a) TQ is deemed ineffective for controlling hemorrhage
      (b) Bleeding can be controlled by other methods, such as with direct pressure, pressure bandage, and/or deep-wound packing
      (c) If there is any potential delay in evacuation (>2 hours), expose the wound fully and reassess need for TQ around the 2-hour time point
      (d) Refer to K9 TECC Supplement for guidance on TQ conversion.
   iv. Before releasing a TQ on a casualty that has received intravenous (IV) fluid resuscitation for hemorrhagic shock, ensure a positive response to resuscitation efforts (e.g., improving mentation and peripheral femoral pulses are normal).
   v. When time and the tactical situation permit, a distal pulse check should be accomplished on any extremity on which a TQ remains in place. To eliminate a distal pulse or visual hemorrhage, if still present, consider:
      (a) Additional tightening of the TQ, and/or
      (b) Use of a second juxtaposed TQ, side by side and proximal to the first.
   vi. Reasons to consider NOT removing TQ include:
      (a) The distal extremity or tail is a complete amputation
      (b) The K9 casualty remains in shock or is suffering traumatic brain injury (TBI).
      (c) The TQ has been on for >6 hours.
      (d) Medical treatment facility is within 2 hours after time of application.
      (e) Considered inadvisable to transition to other hemorrhage control methods on basis of the tactical or medical situation.
   vii. Expose and clearly mark all TQ sites with the time of TQ application.

f. Consider using a junctional TQ for difficult-to-control junctional hemorrhages (e.g., axilla and inguinal placements) in K9s. Note: The Abdominal Aortic Junctional Tourniquet (AAJT™; Compression Works; http://compressionworks.com) has not been evaluated in K9s, but has been evaluated in swine models and shown effective.

g. Immobilize (i.e., splint) and elevate the injured area whenever feasible.

h. Reassess frequently for evidence of rebleeding.

3. Airway management.
   a. Unconscious casualty without airway obstruction:
      i. Place the K9 casualty in the recovery position, this typically is in a sternal (i.e., prone) position.
      ii. Extend the head and neck into a straight inline position.
      iii. Physically open the mouth and pull tongue forward to help open the airway and allow examination of the mouth and pharyngolaryngeal area.
         (a) Consider using a roll of tape or syringe tube casing (without a plunger) as a mouth gag to keep the mouth open.
   b. K9 casualty with airway obstruction or impending airway obstruction:
      i. Clinical signs: Pawing at mouth, gagging, excessive drooling, frequent swallowing motions, extended head and neck, elbows and upper legs held out from the chest (i.e., “tripod position”), reluctant to lie down, and cyanosis (bluish gums) as a late sign.
ii. Evaluation:
(a) It is not advised to stick your hand into the mouth of a conscious K9. Consider team safety for not suffering bite wounds:
1) Use a leash, rope, or roll gauze looped behind the upper canine teeth to pry the mouth open.
2) If in your scope of practice, consider sedating the K9 in accordance with local veterinary-approved protocols or refer to in the K9 TECC Supplement for chemical-restraint recommendations.
(b) Position the K9 in any position that allows the K9 to breath with minimal restriction of air flow and protects the airway, even if that involves a sitting position.
(c) Observe for bilateral chest rise and fall.
(d) Listen for labored or noisy breathing (e.g., stridor, stertor).
(e) Palpate throat and trachea.
(f) Open airway as described in paragraph 3.a.ii

iii. Intervention:
(a) For patients with an observable obstruction, quickly remove any obvious moveable foreign material from the oropharyngolaryngeal area.
(b) BE CAREFUL not to push the object down further into the airway.
1) If foreign material is not readily visible, DO NOT perform blind two-finger sweep of the mouth and pharynx.
(c) Consider abdominal thrusts (i.e., Heimlich maneuver) for moveable foreign bodies. NOTE: NEVER attempt abdominal thrusts if sharp objects such as sticks or bones are present.
(d) If attempts to clear or remove the object or obstruction from the airway have failed and the K9 collapses, consider initiating:
1) Direct visualization and removal with Magill forceps or similar instrument
2) Chest compressions (100–120 compressions/min)
3) Artificial ventilation via bag-mask-valve technique or mouth to snout at a rate of 8–10/min
4) If within scope of practice and training, pursue advanced airway techniques (e.g., needle or surgical cricothyotomy)
(e) If partial airway obstructions (i.e., some air is able to flow into the lungs), transport as soon as possible and continuously monitor for progression to complete airway obstruction. DO NOT delay on-scene time.

(c) Advanced airway techniques: If previous measures are unsuccessful at clearing the airway, the provider is properly trained, and the intervention is within the provider’s scope of practice, then perform:

i. Orotracheal (OTT)/endotracheal intubation (ETT):
   (a) Preferred technique in K9s for gaining patent airway, because of ease of ETT placement as compared to humans
   (b) To facilitate ETT placement, ensure head and neck are extended (not flexed) and in line. This will allow a direct line of sight or path from the oral cavity through the pharyngolaryngeal area and into the trachea.
   (c) A laryngoscope is not often required for K9 OTT/ETT, but it is helpful.
   (d) Common sizes for a 25–30kg K9 are 9–11mm internal diameter.

ii. Blind insertion airway device:
   (a) Not considered first line. ETT placement is preferred, but consider if ETT is not available.
   (c) Use chemical restraint in accordance with approved veterinary guidelines or K9 TECC Supplement, and local lidocaine, if conscious.

iii. Needle or surgical cricothyrotomy:
   (a) Use the same procedure as described for humans.
   (b) Use chemical restraint in accordance with approved veterinary guidelines or K9 TECC Supplement, and local lidocaine, if conscious.

iv. Needle or surgical tracheostomy:
   (a) Not recommended over cricothyrotomy because it is more invasive, time consuming, and has a higher rate of complications.
   (b) Use chemical restraint (see K9 TECC Supplement or local veterinary approved protocols) and local lidocaine if conscious.

iv. NOTE: If cervical spinal cord injury is suspected, try to maintain the head and neck in a neutral, in-line position; avoid excessive flexion or extension of the neck.

d. Consider administering oxygen supplementation, if available.
e. If no spontaneous ventilations, provide artificial respirations at 8–10/min.
f. Monitor oxygen saturation (if available). Normal values are >94% on room/atmospheric air.
   i. Pulse oximetry probe placement in order of preference: tongue (if unconscious), lip, ear pinna, prepuce (male) or vulva (female).
4. Respiration.
   a. All open and/or sucking chest wounds should be treated by immediately applying a gloved hand over wound, followed by a vented or nonvented occlusive seal to cover the defect.
      i. Rapidly clip hair (if feasible; this is not necessary) around the wound, to allow the seal to become airtight. Note: Clipping is often not a necessary step, because of the elasticity of K9 skin.
      ii. If hair clippers are not available, place a water-soluble lubricant (or other water-soluble medium, e.g., blood) on the underside of the chest seal to form an occlusive seal between the skin and the chest seal.
      iii. Secure in place on all four-sides (vented or nonvented) with adhesive tape.
   b. Monitor the casualty for the potential development of a subsequent tension pneumothorax (T-PTX).
   c. Consider the presence of a T-PTX in the setting of known or suspected thoracic trauma AND include progressive respiratory distress and increasing respiratory rate, with the following clinical signs:
      i. Rapid, shallow, and open-mouth breathing
      ii. Acting agitated or unable to get comfortable
      iii. Head and neck extended and elbows and upper front legs held out away from body (i.e., tripod position)
      iv. Asynchronous breathing pattern (i.e., abdomen and chest move in opposite directions during inspiration)
      v. Barrel-chested with minimal chest excursion (more abdominal component)
      vi. Lack of drive and response to even basic commands, unwillingness to move
      vii. Reluctance to lie down
      viii. Cyanotic (blue) gums (a late finding)
      ix. Collapse
   d. If T-PTX is present or develops, consider:
      i. "Burping" the occlusive chest seal, AND/OR
      ii. Needle decompression (if within scope of practice and training)
         (a) Performed with a 14-gauge, 2- to 3.25-inch (8cm) needle/catheter
         (b) Insert in the seventh to ninth intercostal space midway up the lateral thoracic wall.
         (c) Ensure that the needle enters cranially (i.e., toward the head) of the rib.
         (d) Insert the needle perpendicular to the chest wall.
   e. Penetrating thoracic foreign body (e.g., knife, arrow, rebar):
      i. If still in place, DO NOT REMOVE but SECURE object in place. Only consider removing impaled object if it:
         (a) Interferes with establishing a patent airway or performing cardiopulmonary resuscitation (CPR);
         (b) Cannot be adequately secured in place for evacuation or transport; or
         (c) Cannot be removed from the scene or transported with the K9 (e.g., K9 impaled on rebar sticking out from a concrete flooring).
      ii. Place occlusive seal (e.g., saran wrap, meal ready-to-eat wrapper, commercial chest seal) around the impaled object and seal edges of occlusive seal with adhesive tape.
      iii. Stabilize and secure (e.g., with bandaging) the foreign body to prevent further injury.
      iv. Perform needle decompression as needed if T-PTX develops.
      v. Transport (injury up) as soon as possible with no pressure on penetrating object.
   a. If evacuation to definitive care is >30 minutes, consider placing at least an 18-gauge IV catheter (or larger bore) in at least one peripheral vein (the cephalic vein in either front leg is preferred).
   b. If resuscitation is required and IV access is not obtainable, use the IO route (per agency protocol and training). Recommended IO locations in the K9, in order of preference:
      i. Flat anteromedial surface of the proximal tibia (1–2cm distal to the tibial tuberosity; preferred route, because of ease of placement and location of landmark; 15–25 mm IO catheters often work well).
      ii. Greater tubercle of the humerus. (Similar insertion technique as humans). Often requires an adult-length IO catheter.
6. Tranexamic acid (TXA) or epsilon-aminocaproic acid (EACA).
   a. If casualty is anticipated to need significant blood transfusion (e.g., presents with hemorrhagic shock, one or more amputations, penetrating torso trauma, or evidence of severe bleeding) consider administration of one of the following as soon as possible and NO LATER than 3 hours postinjury:
      i. 10 mg/kg TXA in 100mL normal saline (NS) or lactated Ringer’s solution (LR) IV slowly over 15 minutes.
      ii. 150mg/kg EACA in 100mL NS or LR slowly over 15 minutes; may continue as an infusion at 15–20mg/kg/h for 8 hours.
   b. NOTE: Evidence supporting the appropriate dosage of TXA or EACA in K9s is currently limited. Studies are being conducted.

7. Fluid resuscitation.
   a. Assess for hemorrhagic shock
      i. Altered mental status (in the absence of head injury) and weak/absent peripheral femoral pulses are the best field indicators of shock.
      ii. Abnormal vital signs:
         (a) Systolic blood pressure (SBP) <90mmHg and heart rate >140 bpm, or a shock index (HR/SBP) >1.
         (b) Refer to K9 TECC Supplement or K9 TECC resources page (http://www.k9tecc.org/resources.html) for expected changes in K9 vital parameters.
   b. NOT in shock:
      i. No IV fluids necessary.
      ii. Per os (PO) fluids permissible if:
         (a) Conscious, able to swallow, and has no injury requiring potential surgical intervention, AND
         (b) Confirmed long delay in evacuation to care.

8. If in shock:
   a. Goal is to maintain perfusion, not necessarily to restore to normal perfusion values.
   b. Administer appropriate IV fluid bolus and reassess casualty’s perfusion parameters (in accordance with local veterinary-approved protocols or refer to the K9 TECC Supplement for fluid resuscitation protocols).
      i. Repeat bolus as appropriate based on clinical response.
   c. If K9-specific blood products are available, consider resuscitation with fresh-frozen plasma (FFP) and packed red blood cells (PRBCs) in a 1:1 ratio.
   d. If a K9 casualty with an altered mental status due to suspected TBI has a weak or absent peripheral pulse, resuscitate as necessary to maintain a desired SBP ≥90mmHg or a strong palpable femoral pulse. Avoid restoring SBP >120mmHg with suspected TBI.

   a. Minimize casualty’s exposure to the cold elements.
   b. Move patient from cold environment or element to warm shelter.
   c. Transport patient in a horizontal/sternal position.
   d. Remove any wet outer wear (e.g., vests, harnesses, booties).
   e. Gently pat dry any wet tissues or hair coat. Avoid vigorous rubbing.
   f. Place the casualty on an insulated surface as soon as possible.
   g. Cover the casualty with a commercial warming device, dry blankets, poncho liners, sleeping bags, or anything that retains heat and keeps the casualty dry.
   h. ALWAYS handle markedly hypothermic patients (i.e., < 86°F [30°C]) gently to avoid triggering cardiac dysrhythmias.
   i. Primary efforts should concentrate on treating and preventing hypothermia (as described above) and transporting patient gently to a medical care facility.

10. Ocular (eye) trauma.
    a. Consider flushing the affected eye and adjacent tissues with copious amounts of sterile saline or ophthalmic rinse.
    b. Nonpenetrating injuries:
       i. Protect the eye from further injury.
       ii. If available, place a commercial or improvised (e.g., bucket with bottom cut out) Elizabethan-type collar on the K9 to prevent self-trauma.
       iii. Consider covering the uninjured eye to reduce the level of anxiety as well as reduce “sympathetic” movement of the injured eye.
    c. Penetrating eye trauma:
       i. If a penetrating eye injury is noted or suspected, protect the eye from external pressure and stabilize any impaled object to prevent movement during extraction.
       d. Refer to K9 TECC Supplement or local veterinary-approved guidelines under “Ocular Trauma” for further guidance.

11. Reassess casualty.
    a. Perform secondary survey (head-to-tail full-body examination), checking for additional injuries. Reassessment includes:
       i. Inspection (visual observation),
       ii. Palpation (hands-on assessment), and
       iii. Auscultation (auditory assessment).
    b. Consider focused assessment of identified localized injured areas.
    c. Reassess vital parameters (e.g., heart rate, respiratory rate, pulse quality, capillary refill).

12. Wounds and fractures.
a. **Important:** Handle an injured K9 with a fracture with extreme care and proper restraint. Consider administering a chemical restraint and analgesia before manipulating the fractured site. (Refer to K9 TECC Supplement for drug protocols.)

b. Inspect for and dress additional closed or open wounds and fractures:
   i. Consider splinting known or suspected fractures if time and resources permit.
   ii. Rapidly identify and attend to open abdominal wounds.

   c. Refer to K9 TECC Supplement or follow local veterinary-approved guidelines for wound and fracture management protocols.


   a. Provide adequate analgesia as necessary for the injured K9.
   b. For K9s able to continue mission:
      i. **DO NOT** use any human-derived nonsteroidal antiinflammatory medications (e.g., aspirin, ibuprofen, naproxen, ketorolac) in K9s.
      ii. When available, consider: tramadol 3–5mg/kg every 6–8 hours PO (75–125mg for a 25kg K9).
      iii. Use caution when attempting to administer oral medications to an injured K9 in pain.
   c. For K9s unable to continue mission:
      i. Consider narcotic (opiate) medications.
         (a) IV, IO, or intramuscular (IM) pure mu (µ)-agonist opiates (e.g., morphine, fentanyl, hydromorphone) are the most effective.
         (b) **NOTE:** Oral opiates are not effective and intranasal/transmucosal fentanyl (e.g., lozenges) have not been fully evaluated in K9s.
      ii. Consider ketamine (at analgesic dosages) for moderate to severe pain.
         (a) Ketamine must be combined with a benzodiazepine (e.g., midazolam, diazepam, lorazepam) in K9s.
         iii. Consider adjunct administration of antiemetic medications (e.g., ondansetron).
      d. Refer K9 TECC Supplement or local veterinary-approved guidelines for analgesia protocols.


   a. Consider initiating antibiotic administration for K9 casualties with open wounds or fractures, or penetrating eye injury when evacuation to definitive care is significantly delayed or infeasible.
   b. This is generally determined in the mission planning phase and requires medical oversight.
   c. If antibiotics are warranted, select either a cephalosporin or potentiated penicillin (e.g., amoxicillin-clavulanic acid, cephalexin).
   d. **NOTE:** Ertapenem: Currently, there are no pharmacokinetic data on this antibiotic use in K9s. Because of the very limited information available regarding its use in K9s, it is considered an investigational treatment. If this is the only antibiotic available, then suggested dosage is to use the human pediatric dose of 15mg/kg IV or IM every 12 hours, not to exceed a daily dosage of 1g (e.g., 25kg OpK9 = 375mg dose).

15. Burns.

   a. **Important:** Analgesia in accordance with K9 TECC guidelines should be considered for all K9 burn casualties.
   b. Consider burns may not be readily evident in K9s because their hair coat covers skin lesions effectively.
      i. Hot liquids seep under hair coat and, therefore, only an area of wet, oily, or greasy hair may be present.
      ii. A K9 often reacts to a painful burn by displaying agitation and continually biting, licking, or rubbing the affected area. Look for these behavioral signs to help support any suspicion that a K9 may have been burned.
   c. Immediately remove the K9 from the burning source and stop the burning process.
      i. Remove all harnesses, collars, vest, booties, and so forth. Avoid pulling away any items that are melted and have stuck to the K9’s skin.
   d. Consider inhalational/airway injury in any K9 trapped in a confined-fire environment and with any one of the following clinical signs: carbonaceous sputum, singed facial or nasal hairs, facial burns, oropharyngeal edema, vocal changes (stridorous), or altered mental status.
      i. Facial burns, especially those that occur in closed spaces, may be associated with inhalation and corneal injuries.
      ii. Aggressively monitor airway status and oxygen saturation (SpO₂) in such patients and consider early definitive airway management for respiratory distress or oxygen desaturation. **Note:** Consider SpO₂ may appear normal because most devices do not differentiate between carbon monoxide (CO) and oxyhemoglobin.
   e. Consider treating ocular/corneal injuries (e.g., flushing eyes, applying topical nonpreserved lubricant).
   f. **Smoke inhalation,** particularly in a confined space, may be associated with significant CO and cyanide toxicity. Patients with signs of significant smoke inhalation plus:
      i. Significant symptoms of CO toxicity should be treated with high-flow oxygen, if available.
ii. Significant symptoms of cyanide toxicity should be considered candidates for cyanide antidote administration, if available (see K9 TECC Supplement for cyanide antidote options).

g. Estimate total body surface area (TBSA) burned to the nearest 10%, using the appropriate, locally approved burn TBSA estimate calculation (see K9 TECC Supplement or see www.k9tecc.org/resources for K9 Casualty Care Card).

h. Local and minor burns (i.e., superficial or partial thickness <15% TBSA): Consider cooling burned skin with cool to cold water (sterile fluid, if available) within 20 minutes of burn incident.
   i. Avoid actively cooling (e.g., irrigation, application of ice) burns >15% TBSA to prevent inducing hypothermia.
   ii. Cover the burn area with dry, sterile dressings and initiate measures to prevent heat loss and hypothermia once cool irrigation is completed (if performed).
   iii. For moderate to severe burns (i.e., >20% TBSA) or any full-thickness burn (i.e., third or fourth degree):
      i. Fluid resuscitation should be initiated as soon as IV/IO access is established. (Refer to K9 TECC Supplement under “Burns.”)
      ii. If hemorrhagic shock is also present, resuscitation for hemorrhagic shock takes precedence over resuscitation for burn shock. (Refer to K9 TECC Supplement under “Shock – Fluid Resuscitation” or locally approved veterinary guidelines.)
      iii. DO NOT actively cool by applying ice and/or water to burned area.
      iv. Cover the burn area with dry, sterile dressings and initiate measures to prevent heat loss and hypothermia once cool irrigation is completed, if performed.
      v. Aggressively act to prevent hypothermia for burns >0% TBSA.
   j. All previously described casualty care interventions can be performed on or through burned skin for a burn casualty.

   a. Periodically, obtain and record vital signs (i.e., temperature, pulse, respiration, pulse quality, mucous membrane color, capillary refill time, mentation).
   b. If available electronically, monitor:
      i. SpO₂ via tongue (if unconscious), lip, ear pinna, prepuce or vulva, rectum (if rectal probe available)
      ii. Electrocardiogram
      iii. End-tidal carbon dioxide (ETCO₂) level (if intubated)
      iv. Noninvasive blood pressure
   17. Prepare K9 casualty for movement.
      a. Consider environmental factors for safe and expeditious evacuation.
      b. Secure casualty to a movement-assist device, when available.
      c. If vertical extraction is required, ensure casualty is secured within appropriate harness, equipment is assembled, and anchor points are identified.

18. Communicate with the K9 casualty to provide reassurance.
   a. If available, ensure K9 handler travels with the K9 to provide restraint, comfort, and reassurance (this is important for both the handler and the K9).
   b. Encourage and provide positive reassurance to the injured K9 by stroking the K9’s hair coat and/or patting the K9 on the head if they are not aggressive.

   a. CPR within a tactical or high-threat environment for victims of blast or penetrating trauma who have no pulse, no ventilations, and no other signs of life is not often successful and, therefore, should not be attempted during ITC. May have a greater role for consideration during the evacuation phase.
   b. May benefit those patients suffering cardiopulmonary arrest (CPA) after electrocution, hypothermia, atraumatic arrest, or submersion injury and, therefore, should be considered in the context of the tactical situation.
   c. Consider bilateral needle decompression for K9 casualties suffering torso or polytrauma with no respirations or pulse to ensure T-PTX is not the cause of cardiac arrest before discontinuation of care.
   d. Refer to K9 TECC Supplement or K9TECC resources (www.k9tecc.org/resources) for veterinary CPR guidelines.

20. Documentation of care.
   a. Document clinical assessments, treatments rendered, and changes in the casualty’s status in accordance with local protocol.
   b. Forward this information with the casualty to the next level of care.
   c. Consider implementing a K9 Casualty Care Card (located in K9 TECC Supplement and at www.k9tecc.org/resources) that can be quickly and easily completed by a nonmedical first responder.

ITC Warm Zone Skill Set

1. Hemorrhage control.
   a. Apply direct pressure.
   b. Apply pressure dressing.
   c. Apply wound packing.
   d. Apply hemostatic agent.
e. Apply/reassess improvised or elastic tourniquet (last resort).

2. **Airway.**
   a. Apply manual maneuvers (position head and neck, straight and in line).
   b. Perform endotracheal intubation.
   c. Perform needle or surgical cricothyrotomy/tracheotomy.

3. **Breathing.**
   a. Application of effective occlusive chest seal
   b. Assist ventilations with bag-valve-mask.
   c. Apply oxygen.
   d. Apply occlusive dressing.
   e. Perform needle chest decompression (consider bilateral).

4. **Circulation.**
   a. Gain intravascular access.
   b. Gain IO access.
   c. Administer IV/IO medications and IV/IO fluids.
   d. Administer blood products.
   e. Keep warm.

5. **Wound management.**
   a. Protect the injured eye.
   b. Apply dressing for evisceration.
   c. Apply extremity splint.
   d. Initiate basic burn treatment.
   e. Initiate treatment for TBI.

6. **Prepare casualty for evacuation.**
   a. Move casualty (e.g., drag, carry, lift).
   b. Apply spinal immobilization devices.
   c. Secure casualty to litter.
   d. Initiate hypothermia prevention.

7. **Other skills.**
   a. Perform hasty decontamination.
   b. Initiate casualty monitoring.
   c. Establish casualty collection point.

**NOTE:** Care provided within the ITC guidelines is based on individual first responder training and scope of practice, available equipment, local medical protocols, and medical director approval.

**K9 TECC: Cold Zone Evacuation**

**GOALS**

1. Maintain any lifesaving interventions conducted during DTC and ITC phases.
2. Provide rapid and secure extraction to an appropriate level of care.
3. Avoid additional preventable causes of death.

**Principles**

1. Reassess the casualty or casualties.
2. Use a triage system or criteria per local policy that consider priority AND destination and includes both human and K9 casualties.
3. Use additional resources to maximize advanced care.
4. Avoid hypothermia.
5. Communication is critical, especially between tactical and nontactical EMS teams and veterinary resources.
6. Maintain situational awareness. In dynamic events, there are NO threat-free areas (e.g., green or cold zone)

**Guidelines**

1. **Primary goal.**
   a. The M\textsuperscript{ARCH} principles performed during ITC are similar in evacuation care.
   b. Reassess all interventions applied in previous phases of care, DTC, and ITC.
   c. If multiple wounded (humans and K9s), perform primary triage for priority AND destination.
   d. Consider using the traditional approach to primary assessment by evaluating airway and breathing before bleeding/circulation.

2. **Airway management.**
   a. Unconscious K9 without airway obstruction: **Same as ITC.**
   b. Downed K9 with airway obstruction or impeding airway obstruction:
      i. Initially, same as ITC
      ii. If previous measures unsuccessful, it is prudent to consider OTT/ETT or needle/surgical cricothyrotomy or tracheotomy (with lidocaine, if conscious).
   c. If intubated, reassess for respiratory decline in patients with potential pneumothoraces
   d. Consider the mechanism of injury and the need for spinal immobilization. (See Neurological Trauma below).
      i. Consider most conscious K9s may need chemical restraint to remain immobilized. (**Refer to K9 TECC Supplement or locally approved veterinary protocols**)
      ii. Spinal immobilization may not be necessary for downed K9s with penetrating trauma if the K9 appears neurologically intact.

3. **Breathing.**
   a. Immediately apply an occlusive bandage to all open and/or sucking chest wounds that were not treated before transport.
   b. Monitor the K9 for the potential development of a subsequent T-PTX. Clinical signs of a T-PTX in K9s include, for example, progressive respiratory distress, hypoxia, and/or hypotension in the setting of known or suspected thoracic trauma.
   c. Treat T-PTX as described in ITC (i.e., “burping” chest seal or needle decompression). Repeat steps as needed to mitigate respiratory distress.
      i. **ALWAYS** consider decompressing both left and right sides of the chest in K9s
5. TXA or EACA.
   a. If casualty is anticipated to need significant blood transfusion (i.e., presents with hemorrhagic shock, one or more amputations, penetrating torso trauma, or evidence of severe bleeding), consider administration of one of the following as soon as possible and NO LATER THAN 3 hours postinjury:
      i. 10mg/kg TXA in 100mL NS or LR IV slowly over 15 minutes
      ii. 150mg/kg EACA in 100mL NS or LR slowly over 15 minutes; after initial bolus, may consider continued infusion at 15–20mg/kg/h for 8 hours

   a. Reassess casualty for hemorrhagic shock (i.e., altered mental status in the absence of brain injury, weak or absent peripheral pulses, and/or change in pulse character).
   b. Establish IV or IO access, if not performed already performed in ITC.
   c. Restore perfusion as recommended in ITC. (Refer to K9 TECC Supplement for shock and fluid resuscitation.)
   d. If BP monitoring is available, maintain a SBP of 80–90mmHg.
      i. For a K9 casualty with an altered mental status due to suspected TBI, maintain a desired SBP >90mmHg or a strong palpable femoral pulse.
         (a) For TBI, consider using a low-volume fluid strategy comprising hypertonic saline combined with a synthetic colloid.
      ii. If in shock and K9-specific blood products are available, with appropriate provider scope of practice/local protocols, resuscitate with 1:1 ratio of PRBCs to FFP.
         (a) If K9 blood-component therapy is not available, consider collecting and transfusing fresh whole blood, if veterinary-approved protocols, appropriate training, and methods of compatibility testing are in place.
   e. Further administration of IV fluids to maintain hemodynamic stability must take into the consideration transport time as well as the adverse effects on the patient that may be invoked by using large-volume fluid resuscitation.
      i. If transport times are anticipated to exceed 2 hours, consider administering small aliquots of fluids to maintain targeted BP/clinical perfusion parameters or consider starting a low-rate infusion of:
         (a) Synthetic colloids (low-molecular weight, preferred) at 1mL/kg/h, OR
         (b) Isotonic crystalloids at 2mL/kg/h

a. Minimize casualty’s exposure to the elements; move into medic unit, vehicle, or warmed structure, if possible.
b. If not performed already during previous phases of care:
   i. Remove any wet overgarments and dry the casualty.
   ii. Place the casualty on an insulated surface as soon as possible.
   iii. Cover the casualty with commercial warming device, dry blankets, poncho liners, sleeping bags, or anything that will retain heat and keep the casualty dry.
c. If available and required to maintain perfusion, provide warm IV fluids.

8. Monitoring.
a. Periodically, obtain and record vital signs (i.e., temperature, pulse, respiration, pulse quality, mucous membrane color, capillary refill time, mentation)
b. If available, electronically monitor:
   i. Pulse oximetry
   ii. Electrocardiogram
   iii. ET CO₂ (if intubated)
   iv. Noninvasive blood pressure

c. If available, electronically monitor:
   i. Noninvasive blood pressure
   ii. Electrocardiogram
   iii. ET CO₂ (if intubated)
   iv. Noninvasive blood pressure

a. Perform secondary survey to check for additional injuries.
b. Inspect/dress known wounds and splint known/suspected fractures that were previously deferred.
   Recheck pulses/warmth of bandaged limbs.
c. Attend to any suspected or known blunt or penetrating eye injuries:
   i. Protect the eye from external pressure.
   ii. Stabilize any impaled object to prevent movement during transport and movement.
d. Important: Handle an injured K9 with a fracture with extreme care and proper restraint. Consider administering a chemical restraint and analgesia before manipulating the fractured site.
e. Refer to K9 TECC Supplement for Wound and Ocular Trauma Management and recommended analgesia/chemical restraint protocols.

10. Analgesia/sedation.
a. Provide adequate analgesia as necessary as described under ITC and K9 TECC Supplement.
b. DO NOT use any human-derived nonsteroidal antiinflammatory medications (e.g., aspirin, ibuprofen, naproxen, ketorolac) in K9s.

11. Antibiotics.
a. Consider initiating antibiotic administration for K9 casualties with open wounds/fractures and penetrating eye injury when evacuation to definitive care is significantly delayed or infeasible.
b. This is generally determined in the mission planning phase and requires medical oversight.
c. If antibiotics are warranted, select either a cephalosporin or potentiated penicillin (e.g., amoxicillin-clavulanic acid, cepalexin).

a. Consider burns may not be readily evident in K9s because their hair coat covers cutaneous lesions effectively.
b. Burn care is consistent with the principles described in ITC. For recommended interventions refer to the “Burns” section in K9 TECC Supplement.
c. Smoke inhalation, particularly in a confined space, may be associated with significant CO and cyanide toxicity. Patients with signs of significant smoke inhalation plus:
   i. Significant symptoms of CO toxicity should be treated with high-flow oxygen, if available.
   ii. Significant symptoms of cyanide toxicity should be considered candidates for cyanide antidote administration. (Refer to K9 TECC Supplement for cyanide antidote options.)
de. Be cautious of off-gassing from patient in the evacuation vehicle if there is suspected chemical exposure (e.g., cyanide) from the fire.
e. Consider early airway management if there is a prolonged evacuation period and the patient has signs of significant airway thermal injury (e.g., singed facial hair, oral edema, carbonaceous material in the posterior pharynx, and respiratory difficulty).
f. Provide adequate analgesia for all burn patients.
g. Aggressively act to prevent hypothermia for burns >20% TBSA.

13. Prepare K9 casualty for movement.
a. Consider environmental factors for safe and expeditious evacuation.
b. Secure casualty to a movement-assist device when available.
c. If vertical extraction is required, ensure casualty is secured within appropriate harness, equipment is assembled, and anchor points are identified.

14. Communicate with the K9 casualty to provide reassurance.
a. If available, ensure K9 handler travels with the K9 to provide restraint, comfort, and reassurance (this is important for both the handler and the K9).
b. Encourage and provide positive reassurance to the injured K9 by stroking the K9’s hair coat and or patting the K9 on the head if the K9 is not aggressive.

15. CPR.
a. May have a beneficial role for patients suffering CPA from electrocution, hypothermia, nontraumatic arrest, or drowning
b. Note: Consider bilateral needle decompression for casualties with thoracic or blunt polytrauma
with no respirations or pulse to ensure T-PTX is not the cause of CPA before discontinuation of care.

- For CPR guidelines in K9s, see recommendations listed in K9 TECC Supplement, under CPR.

   a. Contact and relay the following information to the receiving veterinary facility:
      i. Estimated time of arrival
      ii. Mechanisms of the injury sustained (e.g., smoke inhalation, blunt versus penetrating trauma)
      iii. Index of suspicion for the seriousness of unseen injuries
      iv. Initial and trends in vital parameters
      v. K9’s known or suspected injuries
      vi. Overall condition or status (e.g., vital signs, mentation, neurological)
      vii. Interventions performed
      viii. Patient’s response to interventions
   b. Continue or initiate documentation of clinical assessments, treatments rendered, and changes in the casualty’s status, in accordance with local protocol.
   c. Transfer information with the casualty to the next level of care either verbally or in writing.
   d. Considering implementing a K9 Casualty Care Card (see K9 TECC Supplement).

SKILL SET:
1. Familiarization with advanced monitoring techniques
2. Familiarization with transfusion protocols
3. Advanced airway management

K9 TECC DISCLAIMER:
The information and resources made available by the K9 TECC working group do not provide authorization for nonveterinary licensed personnel to practice veterinary medicine without the direct or indirect supervision from a licensed veterinarian. The available resources are, rather, intended to be used as a template and/or reference to assist each EMS/Fire/LE agency in developing their own prehospital protocols and standing orders for rendering emergency lifesaving preveterinary care to OpK9s injured in the line of duty.

Further the K9 TECC working group advises:
1. Each agency’s guidelines and standing orders should be developed in collaboration and partnership with a veterinarian licensed in their state or region.
2. These resources are intended to be used ONLY:
   a. For rendering emergency lifesaving care to OpK9s injured in the line of duty when licensed veterinary professionals are not readily available to render care, AND
   b. By licensed or certified EMS paraprofessionals (EMTs, advanced EMTs, paramedics), LEOs, and/or K9 handlers in accordance with the level of their legal scope of practice for providing medical care to human casualties, and by their respective state’s:
      i. Veterinary Practice Act or statutes regulating the practice of veterinary medicine, AND
      ii. Practice acts or statutes of their respective profession (e.g. state EMS statutes)
   c. By the aforementioned personnel that have received training in K9 anatomy, K9 first responder care, and K9 TECC procedures under the direction of a licensed veterinary professional or a professional training organization that employs a licensed veterinarian as a medical director to oversee their training curriculum.

The practice of veterinary medicine is defined and governed on a state-by-state basis. The requirements and exemptions for practicing veterinary medicine may be

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EMR, emergency medical responder; EMT, emergency medical technician; LEO, law enforcement officer.

*Only with special training, specialized protocol, and agency/OMD approval. Ideally, this skill set should be performed by all providers, but need to prove safety and efficacy before inclusion of additional provider levels. Other EMS/medical-related skills such as patient assessment, chest seal placement, splinting, and hypothermia management, should be considered standard for all levels of providers. Additional skills can be considered with agency approval.
found in the respective state’s Veterinary Practice Act or in a section of the state’s laws that regulates veterinary medicine.

Bibliography


Drs Palmer and Yee are co-leads of the K9 Tactical Emergency and Casualty Care Working Group. Guidelines, K9 TECC working group, and further resources are available at: http://www.k9tecc.org/index.html.

Keywords: canines; K9s; Operational K9s; tactical emergency casualty care
Inside this Issue:

- TCCC Guidelines Change 16-03
- Assessment of Trainer Skill
- Bioelectric Dressing for Blister Management
- Rapid Vision Correction by SOF
- Role 1 Resuscitation Team and REBOA
- Preparing to Deploy to a Medically Austere Theater
- Manikin Human-Patient Simulator Training
- Complication of Attempted Surgical Airway
- Albumin Fluid Resuscitation in TCCC
- QuikClot® Combat Gauze™ Use in Afghanistan
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