

## Abstract

Daxor Corporation operated under DoD Phase I SBIR (W81XWH19C0048), Phase II SBIR (W81XWH20C0025), and Sequential Phase II SBIR (HT942523C0050) contracts to build a simple-to-use rapid, portable, and robust point-of-care (POC) blood volume measurement device. The device was validated against the existing gold standard blood volume test (BVA-100, Daxor Corp., Oak Ridge, TN) to have 95% or greater accuracy quantifying patient total blood volume, plasma volume, and red blood cell volume; to calculate excess or deficit of these volumes versus precise patient-specific blood volume norms; and provide patient-specific fluid resuscitation and red blood cell transfusion guidance. The novel device is expected to enable more timely and appropriate interventions and more efficient use of clinical resources as compared to present standard of care (SOC). The device is applicable for the treatment of a range of medical conditions affecting millions of US patients annually, including heart failure, kidney disease, hypertension, sepsis, and perioperative care.

## Introduction

Current clinical standards for fluid management rely on subjective physical assessment and surrogate markers of intravascular blood volume status, which are neither sensitive nor specific.<sup>1-4</sup> Blood volume analysis (BVA-100) utilizes the gold standard indicator dilution technique to directly quantify the amount of circulating Total Blood Volume (TBV), Plasma Volume (PV), and Red Blood Cell Volume (RBCV) and patient specific excess or deficit (vs healthy ideal) as a percentage or deviation in mL. A recent retrospective propensity-matched control analysis demonstrated a 56% reduction in 30-day readmissions, an 82% reduction in 30-day mortality, and an 86% reduction in 365-day mortality for ADHF inpatients whose care was augmented by BVA measurements.<sup>5</sup> Additionally, use of BVA-100 in the treatment of Surgical ICU patients (n=100, Avg APACHE II score 25) served as an effective adjunct for resuscitation, transfusion, and/or de-resuscitation resulting in 66% mortality reduction vs SOC alone.<sup>6</sup> These results point to the outcome improvement possible when physicians have precise diagnostic data to guide volume-adjusting interventions in addition to standard care.

Daxor Corporation operated under U.S. Army and Defense Health Agency contracts with the objective of creating a POC version of the BVA-100. Primary performance parameters were:

- 1) 95% accurate vs existing gold standard (BVA-100)
- 2) Test results in less than 20 minutes
- 3) Point of care
- 4) EMR integration

Daxor successfully produced a compact, portable, battery-operated whole blood volume analyzer (BVA). This new medical device provides accurate blood volume results with a single whole blood sample. The device hardware and software and clinical test process are greatly improved compared to the predicate lab-based BVA-100 analyzer. The test is performable at POC within 20 minutes vs over one hour for the BVA-100. With this new device, Daxor will be able to provide a significant reduction in test time for both military and civilian end users.

## Methods and Materials

Daxor worked with end user and human factors expert consultants and identified three key areas for redesign to achieve the objectives of military use;

- 1) Elimination of the need for any laboratory processing of samples
- 2) Reduction in size of the instrument
- 3) 510(k) Submission to the FDA

## Methods and Materials, cont.

Objective 1) required the design of a Whole Blood Collection Cartridge (WBCC, patent-pending), which allows a precise amount of blood to be contained and then inserted into the gamma counter for sampling.

Objective 2) required a complete redesign of the instrument, using a small tablet computer component and an all-electronic multi-channel analyzer for the gamma counter. All the components necessitated containment within a portable, ruggedized plastic enclosure. A redesigned user interface (UI) was required to enable touch-screen operation of the device.

Objective 3) involved performing in multiple key human indications to validate the accuracy of the test (heart failure, trauma).

Daxor paused hardware and software development periodically to present to expert consultants who provided feedback on all aspects of design and useability. This feedback resulted in refinements and adjustments to approach throughout.

## Results

Objective 1: Daxor completed design of the WBCC and performed a test manufacturing run. Daxor currently has a manufacture ready version with a tolerance below 1.5%.

Objective 2: Daxor has completed a design and assembled five complete systems of a battery-powered, portable, rugged touchscreen system weighing approximately 10 lbs and having dimensions of 10.6" deep x 4.6" wide x 6.0" tall (0.17 cubic feet) [Fig. 1] vs over 90 lbs and over 4 cubic feet for the BVA-100 predicate [Fig. 2]. A novel user interface (UI) was programmed to enable effective device operation from the touch screen and result delivery [Fig 3, 4 & 5].

Objective 3: Daxor has applied for 510(k) clearance for the BVA-200 device, received by the Center for Devices and Radiological Health (CDRH) of the Food and Drug Administration (FDA) on 1/2/2024. Daxor has received Submission numbers CR240001, CR240001, and K240001 for this submission, which covers the device, as well as the CLIA waiver application for the device (which if approved will allow for the use of the device in broader CLIA-waived settings).

## Discussion

All prototype components have been demonstrated successfully per Phase I and II contract requirements. However, additional testing will be required of the WBCC and device hardware to verify and validate both designs and manufacturing processes to meet FDA specifications. During this process further refinement of designs, in particular reduction of device size and weight, will be evaluated. Daxor has several studies planned in which further prototype quantitative validation for test accuracy vs BVA-100 and collection of qualitative user feedback for useability will be performed. Daxor recognizes that human clinical trials demonstrating improved clinical outcomes, especially reduced mortality, vs SOC will be instrumental in demonstrating the clinical value.



Figure 1. BVA-200 device with touch screen



Figure 2. Predicate BVA-100 with computer monitor

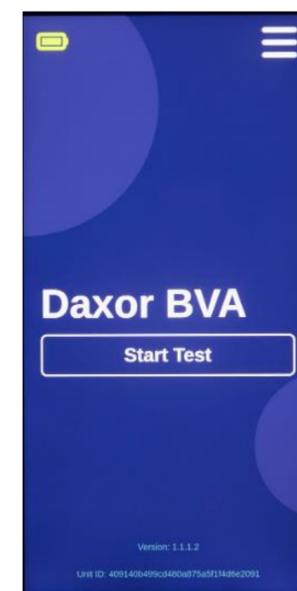


Figure 3. Prototype touch screen user interface menu



Figure 4. Prototype touch screen user interface rest results

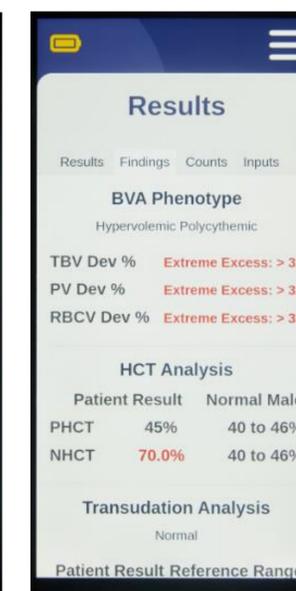


Figure 5. Prototype touch screen user interface scintillation counter graphic

## Conclusions

The Phase I and Phase II contracts have been successfully completed with preliminary results reported. Daxor is currently operating under a DHA sequential Phase II SBIR supporting the completion of some remaining research and development milestones as well as Electronic Medical Record integration of the novel technology. Daxor is also pursuing follow-on funding to support the completion of other efforts.

- 1) Randomized controlled trial vs SOC in target indications (heart failure, hypertension, sepsis) with completion of Clinical Decision Support Software (CDSS) modules to aid fluid management (seeking funding)
- 2) Development of next-generation non-nuclear enhancement of the BVA-200 technology (seeking funding)
- 3) Development of continuous BVA methodologies (seeking funding)