Operational Usability of Real-Time Manual Ventilation Feedback Device in a Military Field Hospital Setting

A Mixed Methods Study

Nichole S. Berge, PhD, NRP

Professor, Training Officer, and EMS Director
North Fork Fire District, Sundance, UT

Disclosures

Financial Support

Research funded by The U.S. Army Medical Research Acquisition Activity.

Industry Relationships

Xinzhi Zhang is an employee of the device manufacturer.

Equipment

All flow-limiting devices utilized in this study were provided free of charge by the manufacturer.

Bias Mitigation

Objective field observations were triangulated with anonymized participant feedback to mitigate bias.

Disclosures

The U.S. Army Medical Research Acquisition Activity, 808 Schreider Street, Fort Detrick MD 21702-5014 is the awarding and administering acquisition office. This work was supported by The Assistant Secretary of Defense for Health Affairs endorsed by the Department of Defense, in the amount of $4,536,252 through the Peer Reviewed Medical Research Program under Award Number HT9425-23-1-0316. Opinions, interpretations, conclusions, and recommendations are those of the author(s) and are not necessarily endorsed by The Assistant Secretary of Defense for Health Affairs endorsed by the Department of Defense.

Acknowledgements

Co-Authors

Xinzhi Zhang and Mark F. Brady, MD, MPH, FACEP

Disclaimer

Information and conclusions do not necessarily represent the official position of the U.S. Army Reserve, the DoD, or the U.S. Government.

Personal Introduction

Clinical & EMS

- Full-Time Firefighter & Paramedic
- EMS Director, North Fork Special Service District
- Instructor, EMT Utah

Academia

- PhD in Higher Education Leadership
- Faculty, Ohio University

Research

- Qualitative Data & Mixed Methods Researcher
- Portfolio of multiple research projects in clinical ventilation

The Clinical Problem

The Skill

Manual ventilation is a critical, life-saving intervention in combat casualty and prolonged field care.[1]

The Challenge

High stress, fatigue, and inconsistent training lead to erratic and unpredictable tidal volumes.

Hyperventilation

Decreased venous return, reduced cardiac output (catastrophic in hemorrhagic shock)[2], and cerebral vasoconstriction which worsens traumatic brain injury (TBI).[3]

Hypoventilation

Insufficient breath delivery resulting in critical hypoxia and severely exacerbated tissue ischemia.

The Training Gap

Current Standard

BLS and TCCC heavily rely on subjective instructor feedback ("visible chest rise").

The Limitation

Subjective metrics lack the precision required to prevent alveolar micro-trauma over extended durations.

The Need

A tool that is not only clinically effective but operationally viable under extreme cognitive load.

Study Setting

Study Objectives

Primary

Usability & Integration

Evaluate usability and operational integration of real-time manual ventilation feedback.

Secondary

Quantitative Impact

Assess quantitative impact on ventilation quality (target tidal volume).

Framework

Technology Acceptance

TAM predicts healthcare tech adoption via two key metrics:[4]

- ***Perceived Usefulness***
- ***Perceived Ease of Use***

Intervention & Procedures

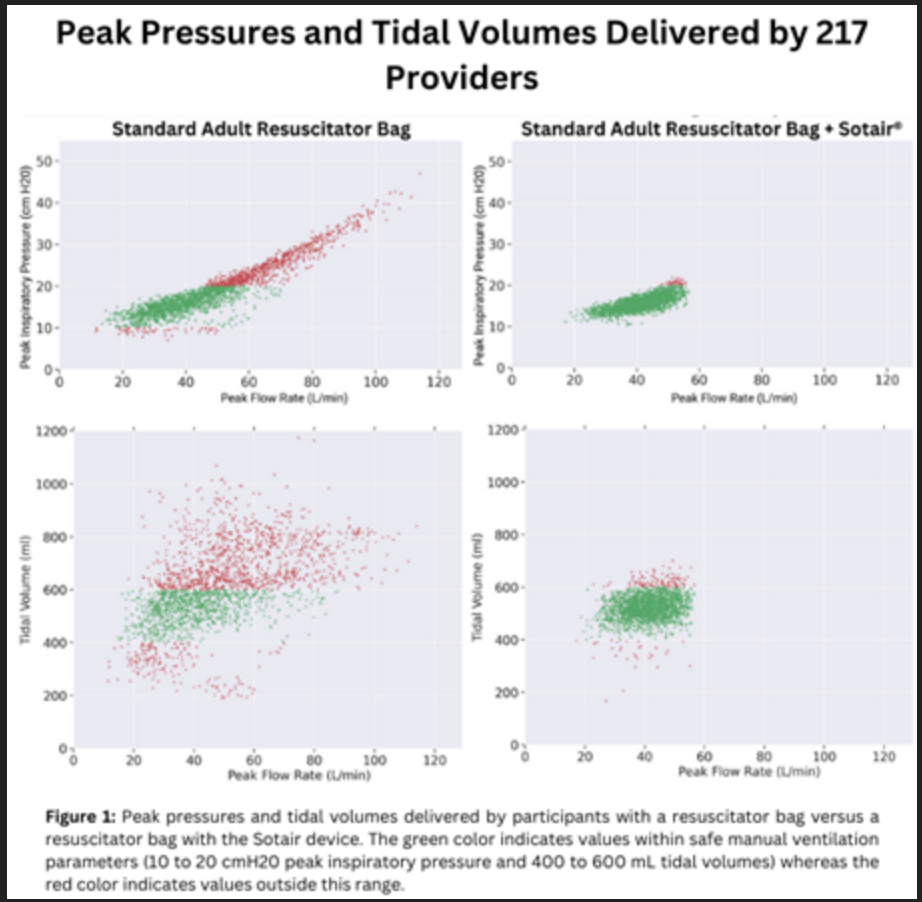


Figure 1: Peak pressures and tidal volumes delivered by participants with a resuscitator bag versus a resuscitator bag with the Sotair device. The green color indicates values within safe manual ventilation parameters (10 to 20 cmH20 peak inspiratory pressure and 400 to 600 mL tidal volumes) whereas the red color indicates values outside this range.

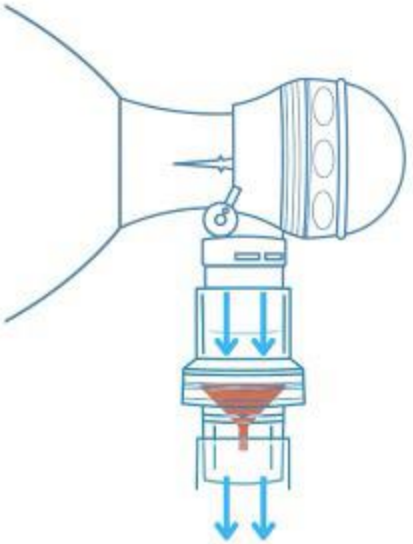
Kumar P, Holley JE, Justice JM, Slutsky AS, Brady MF. Manual ventilation performance in first responders using a flow-rate limiting device (Sotair). Presented at: EMS World Expo's International Scientific Symposium in partnership with UCLA's Prehospital Care Research Forum; September 2024; Las Vegas, NV.

Flow-Limiting Device

Class II FDA 510(k) Cleared
K212905

Mechanism of Action

Forceful Squeeze, >55 LPM
Valve Closed
Limted Air Flow
FEEDBACK: Haptic, Auditory & Visual



Gentle Squeeze, <55 LPM
Valve Open
Air Flow

Intervention & Procedures

Intervention & Procedures

Study Phases & Data Validation

01
Pre-Evaluation
Interview.

02
Baseline
Performance recording (60-second trial).

03
Familiarization
Video instruction & hands-on familiarization.

04
Evaluation
Standalone device evaluation.

05
Post-Evaluation
Interview.

Data Validation

Qualitative findings were triangulated across pre-interviews, direct field observations, and post-interviews.

Participant Demographics

Sample Size

N = 70 military medical personnel.

Experience

Ranged from novice (<1 year) to highly experienced (>30 years).

Certifications

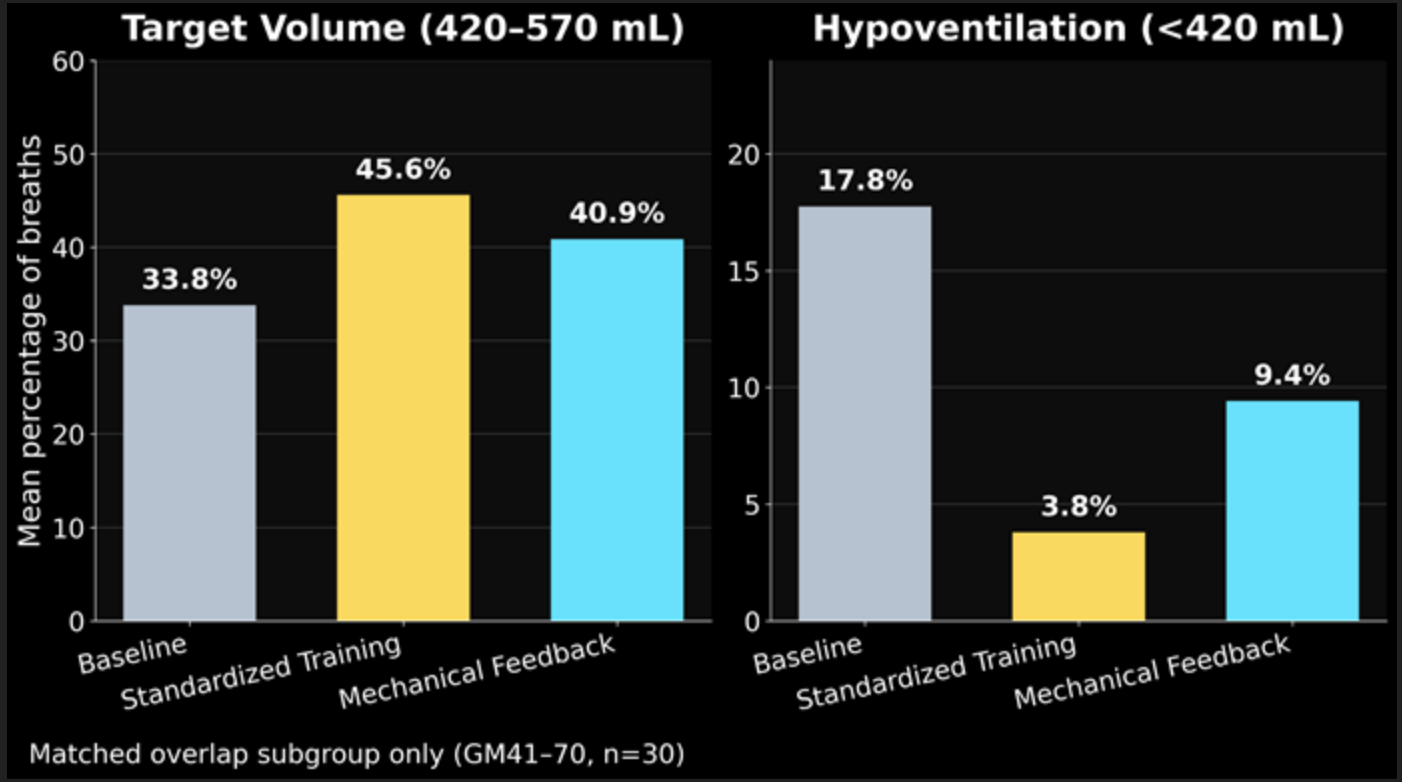
Universal BLS and TCCC; varied ACLS and PALS.

Familiarity

Most "very familiar" with manual ventilation, some training only exposure.

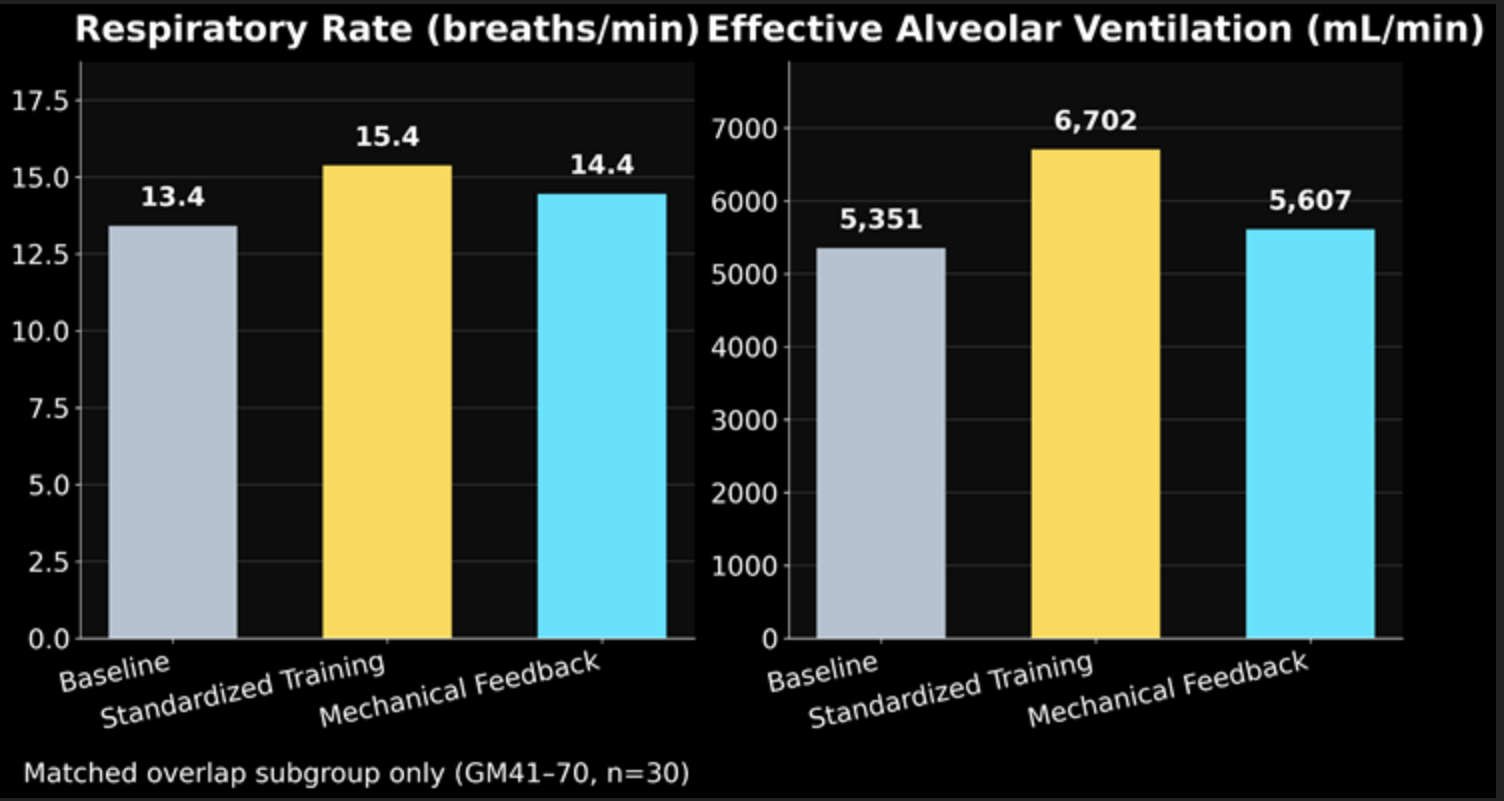
Efficacy – Target Volume & Hypoventilation

Performance Outcomes Across Study Conditions



Safety – Preventing Over-Correction

Physiological Impact of Feedback Regulation



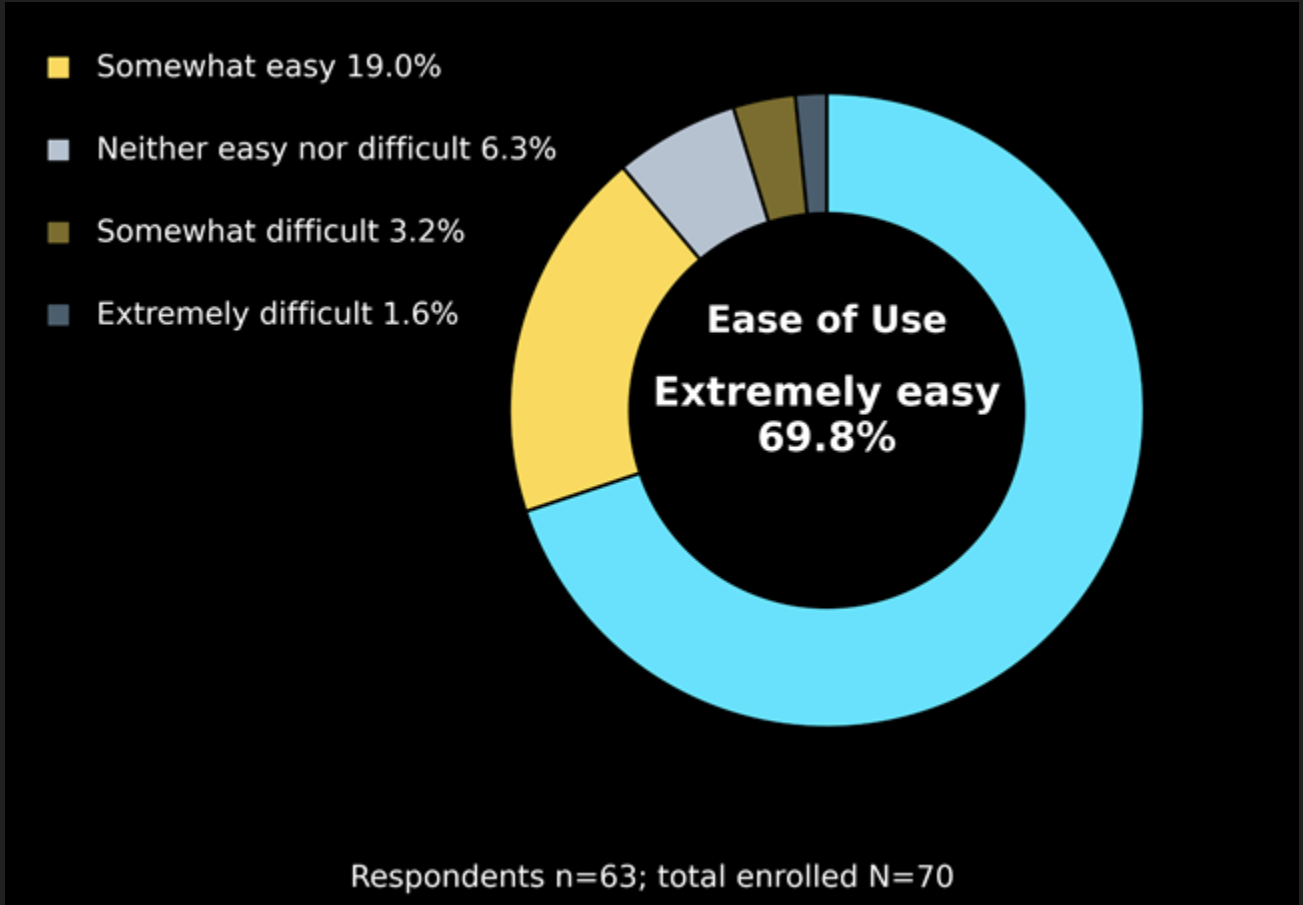
Unintended Consequence

Spiked respiratory rate and minute ventilation (~6.7L), risking gastric insufflation and barotrauma.[5]

Mechanical Advantage

Physical governor safely regulated minute ventilation (~5.6L).

Usability – TAM Perceived Ease of Use



Usability – TAM Perceived Usefulness

Cognitive & Operational Benefits of Feedback Systems

Cognitive Offloading

Haptic/visual feedback eliminated the need for mental calculations like counting seconds or estimating compression depth.

Resource Allocation

Allowed healthcare providers to effectively "outsource" critical breath regulation directly to the assistive device.

Operational Focus

Conserved mental bandwidth is successfully redirected to concurrent resuscitation tasks.

Limitations

Key constraints and boundaries of the evaluation study

Simulation-Based

Unable to report direct patient-centered outcomes, including real-time hemodynamics and overall mortality rates.

Design Constraints

Methodological constraints restricted robust randomization protocols and variable sequencing configurations.

Scope Limitations

The evaluation scope was restricted to a single commercial device class, limiting broader system comparisons.

Conclusion

Key findings and future implications of assisted mechanical feedback

Clinical Impact

Mechanical feedback optimizes tidal volumes and curbs dangerous respiratory rate increases.[6,7]

Field Adoption

Meets TAM criteria for field adoption due to high usability and cognitive offloading benefits.

Scalability

Bridges military and rural EMS applications, with objective sensor data validating subjective operational acceptance.

References

Selected literature and clinical evidence base

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Thank You

For inquiries, feedback, or potential research collaborations, please reach out via email.

Contact

nsberge18@gmail.com