Received: 29 September 2021 | Revised: 5 January 2022 | Accepted: 9 March 2022

DOI: 10.1002/emp2.12710

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
WILEY

BRIEF RESEARCH REPORT

Emergency Medical Services

Physician preferences associated with powered intraosseous access systems: Safety features, reliability, and ease of use

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Funding and support: Funding for this research was provided by Becton, Dickinson and Company.

Abstract

Objective: This study evaluated physician preferences and values related to the most commonly used (traditional) powered intraosseous (IO) system and a novel powered IO system featuring a passive safety needle, battery life indicator, and snap-securement/skin attachment.

Methods: Emergency physicians participated in an IO simulation using both the traditional and novel IO systems. Participants completed a 27-item postsimulation questionnaire to state their preferences toward each IO system and values related to the novel IO system features using a multiple choice, 11-point value ranking scale (0 = no value, 10 = extremely valuable) and free-text answer questions.

Results: Among the 22 study participants, 90.9% (95% confidence interval [CI]: 70.8%, 98.9%) preferred the novel IO system; top reasons for this preference were the novel IO system's passive safety needle and snap-securement/skin attachment. Participants who preferred the traditional IO system (9.1%) noted its ease of use and familiarity. Many physicians preferred the novel IO system's needle (81.8%; 95% CI: 59.7%, 94.8%), powered driver (77.3%; 95% CI: 54.6%, 92.2%), and snap-securement/skin attachment (100%; 95% CI: 84.6%, 100%) compared with the traditional IO system. Safety and ease of use were the most common preference explanations. Of the participants, 100% provided a value score ≥7 for the novel IO system's passive safety needle (mean score, 9.45), whereas fewer participants (59.1%) gave a value score ≥7 for the multilight battery life indicator (mean score, 6.68).

Conclusion: This study demonstrates that emergency physicians prefer and value a novel IO system with features that enhance safety and ease of use. These results provide insight into important factors related to IO systems for emergency physicians.

KEYWORDS
ease of use, emergency physicians, intraosseous device, intraosseous vascular access, safety

Supervising Editor: David Wampler, PhD, LP.

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1 | INTRODUCTION

1.1 | Background

Intraosseous (IO) access is a method for obtaining rapid indirect vascular access during emergent situations when peripheral or central venous catheterization is difficult or unattainable.[1–3] Comparative studies of available IO systems have demonstrated that battery-powered IO instruments are superior to other IO systems (ie, manual, spring loaded) in terms of first-attempt success rates, ease of use, and clinician preference.[4] Despite the demonstrated utility of powered IO systems, little innovation has been applied to these devices since their introduction.

1.2 | Importance

Performance of emergency medical equipment (ie, IO systems) is critical as equipment failure can exacerbate the unique challenges posed by emergent situations. Specific issues with emergency equipment are related to safety, reliability, and ease of use[5] and include needlestick injuries (NSIs),[6] poor battery reliability,[5] and disregard for the impact of ergonomics.[7] Although technical complications with IO systems are generally infrequent,[8,9] the components of a powered IO device (ie, IO needle, reliance on battery power) present emergency physicians with various risks, including NSIs and failed/delayed IO procedures as a result of inadequate battery power.

The variety of powered IO systems and the inclusion of features that enhance the safety, ease of use, and reliability remains limited. The US Food and Drug Administration approved the most commonly used powered IO system (Figure 1A) in 2004, and its design has remained mostly unchanged since its introduction. A novel powered IO system (Figure 1B) with features that improve safety, reliability, and ease of use was recently introduced; however, no studies evaluated the preferences and values regarding these design features.

Physician input has contributed to the innovation of medical devices, highlighting the importance of physician preferences when evaluating novel medical equipment.[10] Clinician feedback is especially important when designing and evaluating products that attempt to decrease occupational risks and improve user experience in emergency settings. Therefore, the current study sought to assess emergency physician preferences and values toward the design elements integrated into a novel powered IO system.

1.3 | Goals of the investigation

The objective of this study was to determine the preferences and values among emergency physicians toward powered IO system features related to safety, reliability, and ease of use.

2 | METHODS

2.1 | Study design and setting

A total of 22 emergency physicians were recruited to participate in a simulated, survey-based study (March 2021 at AdventHealth Orlando) using the most commonly used powered IO system (traditional IO system; EZ-IO IO Access System; Teleflex Medical) and a novel powered IO system with additional features (novel IO system; BD Intraosseous Vascular Access System; Becton, Dickinson and Company). Participants then completed a postsimulation questionnaire designed to assess preferences, values, and attitudes toward the IO systems used in the simulation.

The 2 IO systems used in the study differ in several ways (Figure 1). The traditional IO powered driver has an irreplaceable/non-rechargeable lithium battery and a single light-emitting diode (LED) battery life indicator. The traditional IO system comes with a Needle-

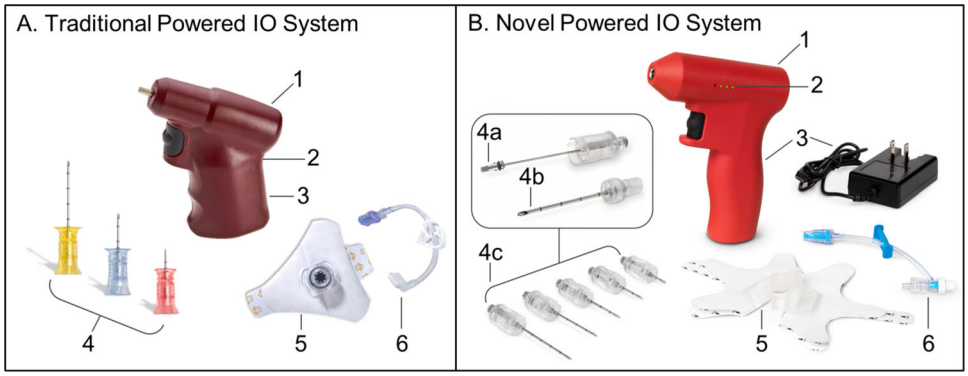

FIGURE 1 The traditional and novel powered intraosseous (IO) systems. (A) The traditional powered IO system features include (1) powered driver, (2) single-light battery life indicator (not shown), (3) irreplaceable/non-rechargeable lithium battery, (4) IO needles of various lengths (15, 25, and 45 mm), (5) telescoping securement/skin attachment; and (6) extension set. The manual sharps securement block included with the traditional IO system is not pictured. (B) The novel powered IO system features include (1) powered driver, (2) multilight battery life indicator, (3) rechargeable battery with power supply, (4a) passive safety mechanism for IO needle stylet, (4b) catheter that is left in place after IO insertion, (4c) IO needles of various lengths (15, 25, 35, 45, and 55 mm), (5) snap-securement/skin attachment, and (6) extension set

The Bottom Line

Intraosseous (IO) access has been shown to provide rapid and reliable access to central circulation in patients in extremis. Little et al describe physician attitudes towards a new powered IO system that includes potentially advantageous features intended to enhance safety, reliability, and ease of use.

VISE (Atrion Medical Products Inc.) manual sharps securement block for needle safety, and this system uses a securement/skin attachment that must be placed before attaching the extension set. Conversely, the novel IO powered driver has a rechargeable battery and a battery life indicator with a multi-LED panel. In addition, the novel IO needle has a passive safety mechanism that automatically surrounds the needle stylet after catheter hub placement. The novel IO system also uses a snap-securement/skin attachment system with a snap-on feature that can open and close around the catheter hub, allowing for its placement after attaching the extension set.

2.2 | Selection of participants

US-based licensed emergency physicians with prior training and facility permission to obtain IO access were recruited. Individuals reporting employment or consulting roles with any medical device companies were excluded. Participants consented to the release of information obtained as a result of their participation.

2.3 | Measurements

The study took approximately 1 hour to complete and included the following 3 sections: (1) participant screening and training, (2) IO simulation, and (3) questionnaire completion.

A 15-minute training session was provided for the traditional and novel IO systems using presentations, animations, and promotional materials. The IO simulation included 5 simulation stations, and both IO systems were provided at each station. The traditional and novel IO systems were used with their respective 25-mm needle kit and securement/skin attachment. IO access injection training blocks (adult humerus reference with 12-mm skinned soft tissue; Sawbones USA, Pacific Research Laboratories, Inc.) were used. Participants were randomly assigned to begin the simulation with either the traditional or novel IO system, and each participant performed a minimum of 2 IO insertions using each system. Unlimited insertions were permitted; however, participants did not exceed 4 insertions with a given IO system.

After the IO simulation, participants used a tablet device to complete a 27-item questionnaire on the Qualtrics Platform (Qualtrics International) that was designed to record (1) IO system preferences and (2) values/attitudes toward the novel IO system features. The questionnaire included multiple-choice questions, 11-point ranking-scale Likert-type questions, and questions with free-text answers. Participants answered multiple-choice questions to identify their preferences and provided free-text answer rationales for each preference. The 11-point ranking-scale questions recorded values/attitudes toward novel IO system features (ie, 0 = no value, 10 = extremely valuable), and ranking rationale was collected using free-text answers.

2.4 | Data analysis

Questionnaire data were analyzed using the Statistical Analysis System 9.4M5 (SAS Institute). All preference questions were analyzed with a 1-sample binomial test, and 95% confidence intervals (CI) were obtained using the Clopper–Pearson (exact) method. Reported *P* values for preference questions were calculated using a 2-sided *z* test. A post hoc power analysis of the overall preference between the traditional and novel IO systems suggested that the number of participants included in this analysis was sufficient (power, 0.988; actual α, 0.017). Descriptive statistics (mean, standard deviation [SD], median, 25th and 75th percentiles) for ranking-scale questions were acquired. Free-text descriptions were categorized by similarity, and means were calculated using Microsoft Excel. Figure creation was performed using GraphPad Prism 8.4.3.

3 | RESULTS

3.1 | Physician preferences regarding powered IO systems

A total of 22 emergency physicians who met the inclusion criteria participated in the study. Physician preference results are presented in Table 1. A significant proportion of the participants preferred the novel IO system overall ($n = 20$; 90.9%; 95% CI: 70.8%, 98.9%; $P = 0.0001$). The main reasons for the overall novel IO system preference were safety ($n = 12$; 54.5%), the snap-securement/skin attachment ($n = 6$; 27.2%), and ease of use ($n = 3$; 13.6%). The 2 participants who preferred the traditional IO system highlighted its ease of use and familiarity with the system.

A significant number of emergency physicians preferred the novel IO needle ($n = 18$; 81.8%; 95% CI: 59.7%, 94.8%; $P = 0.0028$). Improved safety ($n = 14$; 63.6%) and ease of use ($n = 4$; 18.2%) were indicated as the top reasons for their novel IO needle preference. Of the participants, 4 (18.2%) preferred the traditional IO needle because of its ease of use ($n = 3$; 13.6%) and familiarity ($n = 1$; 4.5%).

Participants predominantly preferred the novel IO powered driver ($n = 17$; 77.3%; 95% CI: 54.6%, 92.2%; $P = 0.0105$). These responses were explained with ergonomics ($n = 6$; 27.3%) and rechargeability ($n = 5$; 22.7%). Conversely, 22.7% ($n = 5$) of emergency physicians preferred traditional IO powered driver, and the main reasons were ergonomics ($n = 3$; 13.6%), ease of use ($n = 3$; 13.6%), and improved torque ($n = 1$; 4.5%).

TABLE 1 Powered IO system preferences after the IO simulation

Characteristic	Preferred IO system, $N = 22$			Most common reasons for preference ($N = 22$),[a] *n* providing reason (%)	
	Traditional, *n* (%)	Novel, *n* (%)	95% CI, *P* value	Traditional IO system	Novel IO system
Overall IO system	2 (9.1)	20 (90.9)	70.8%, 98.9% 0.0001	Ease of use: 1 (4.5) Familiarity: 1 (4.5)	Safety: 12 (54.5) Snap-securement/skin attachment: 6 (27.2)
IO needle	4 (18.2)	18 (81.8)	59.7%, 94.8% 0.0028	Ease of use: 3 (13.6) Familiarity: 1 (4.5)	Safety: 14 (63.6) Ease of use: 4 (18.2)
Powered driver	5 (22.7)	17 (77.3)	54.6%, 92.2% 0.0105	Ergonomics: 3 (13.6) Ease of use: 3 (13.6)	Ergonomics: 6 (27.3) Rechargeability: 5 (22.7)
Securement/skin attachment	0 (0.0)	22 (100.0)	84.6%, 100% < 0.0001	N/A	Ease of use: 10 (45.5) Snap-on feature: 4 (13.6)

Abbreviations: CI, confidence interval; IO, intraosseous; N/A, not applicable.

[a]Participants were permitted to provide multiple reasons for their preferences; therefore, the total number of individuals providing a given reason in this section is not equivalent to the total *N*.

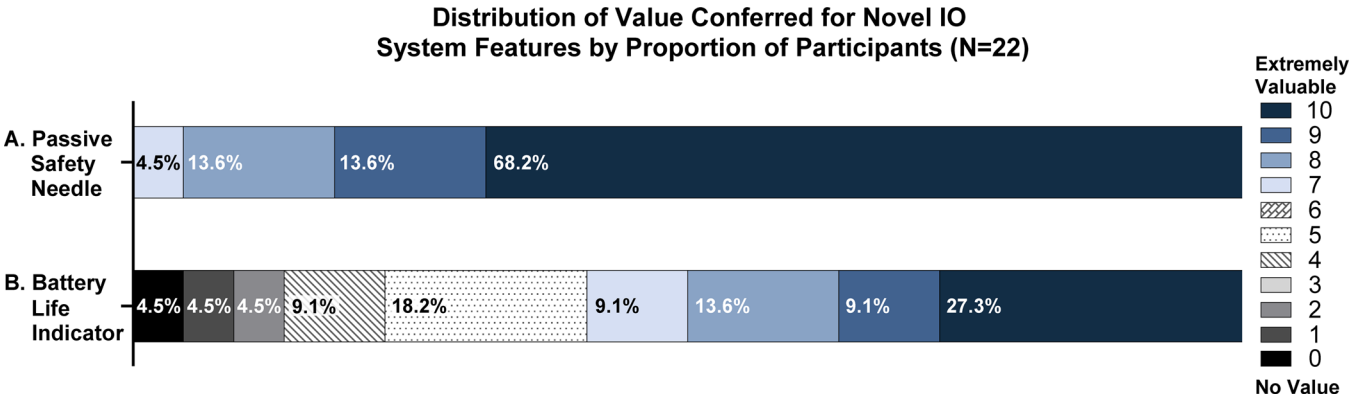

FIGURE 2 Emergency physicians' values toward novel intraosseous system features. The distribution of values given to novel intraosseous system features by proportion of study participants ($N = 22$) as measured by an 11-point value ranking scale (0 = no value, 10 = extremely valuable). (A) Passive safety needle value ranking: mean, 9.45; standard deviation, 0.91; median, 10.00; 25th percentile, 9.00; 75th percentile, 10.00. (B) Battery life indicator value ranking: mean, 6.68; standard deviation, 3.14; median, 7.50; 25th percentile, 5.00; 75th percentile: 10.00

Every participant ($n = 22$; 100.0%; 95% CI: 84.6%, 100%; $P < 0.0001$) preferred the novel IO snap-securement/skin attachment. Common reasons for this preference included ease of use ($n = 10$; 45.5%) and the snap-on feature ($n = 4$; 13.6%).

3.2 | Physician values toward novel IO system features

The 11-point ranking-scale (0 = no value, 10 = extremely valuable) questions were used to determine the value given to various novel IO system features. The mean value score for the passive safety needle was 9.45 (SD, 0.91; median, 10.00), with 68.2% ($n = 15$) of the participants assigning the passive safety needle a value score of 10 (Figure 2A). Furthermore, we found that every emergency physician placed value in the passive safety needle as all participants provided a value score ≥7 ($n = 22$; 100%). The most common reasons provided for the value ranking of the passive safety needle were improved safety ($n = 21$; 95.5%) and benefit during emergent situations ($n = 9$; 40.9%).

The value score for the battery life indicator was lower (mean, 6.68; SD, 3.14; median, 7.50) relative to the passive safety needle, with 59.1% ($n = 13$) of the participants providing a value score ≥7 for the battery life indicator (Figure 2B). Among the individuals who provided a value score of ≥7 ($n = 13$, 59.1%), prevention of a driver with a depleted battery ($n = 5$; 22.7%) and having knowledge of battery life ($n = 4$; 18.2%) were commonly provided rationales. A total of 3 participants (13.6%) who communicated a value score of ≤3 for the battery life indicator stated that they had not experienced battery issues in the past and did not anticipate this feature impacting practice.

Additional results regarding attitudes of emergency physicians toward various novel IO system features are presented in the supplementary materials (Table S1).

3.3 | Limitations

This single-center study had limitations regarding the diversity of participants and the generalizability of the results/conclusions. As this study reports preferences and perceived values, the information collected by this study is non-objective and opinion based. In addition, the IO simulation may not have replicated an actual IO procedure in an emergency department setting. Furthermore, the questionnaire provided participants with the option to disclose their identity; although the data were anonymized for analysis, collection of identifying information may have created a potential source of bias. Future novel IO system investigations should consider capturing data from a larger and more diverse clinician population, collecting data regarding IO system performance and the impact on procedures, and using a clinical setting for the evaluation of IO systems in a real-world application.

4 | DISCUSSION

This brief report provides the first evaluation of a novel powered IO system with a passive safety feature. The study highlights IO system features that are important to emergency physicians and provides insight for improving medical devices used during emergent cases.

We found that emergency physicians prefer an easy-to-use IO system that includes a passive safety needle. It is unsurprising that emergency physicians preferred the IO needle with a passive safety feature, as NSIs occur most frequently in emergency departments.[6] Although previous evidence suggests that powered IO devices are associated with lower NSI incidence compared with manual IO needles,[11] the values given to the passive safety needle by emergency physicians indicate that NSIs are still an important consideration for powered IO access. After safety, ease of use was the second most common rationale provided for physician preferences regarding various IO system characteristics. Although more participants found the overall novel IO system easier to use, several physicians stated that the traditional IO needle, powered driver, and overall system were easier to use. The different perspectives on ease of use may be partially explained by the inherent subjectivity regarding ease of use and familiarity with the commonly used traditional IO system that has been in practice for >15 years.

This study also provides insight into the value given by emergency physicians towards 2 major features of the novel IO system: the passive safety needle and the battery life indicator. Although a clear consensus regarding the value of the passive safety needle was communicated, results varied when evaluating the value of the battery life indicator. Our findings related to the passive safety needle demonstrate that emergency physicians are aware of the risk for NSIs during emergent situations and show preference and value toward features that can enhance safety. However, results varied when emergency physicians were asked to evaluate the value of the battery life indicator, which can prevent disruption of the procedure by warning the user about a low battery before IO placement. Although the majority of study participants provided a value score of ≥7 for the battery life indicator, approximately 40% of the participants ranked it lower in value, suggesting that the battery life indicator may have a relatively modest perceived impact in practice.

Assessment of physician preferences is an essential step in implementing novel medical devices. It has been demonstrated that the adoption of new technologies by clinicians is influenced by the perceived benefit to the patient and how easy it is to use the device.[12] This study shows that ease of use is a major factor in physician preferences regarding powered IO systems. This is consistent with the findings from previous studies evaluating preferences for IO system features,[13,14] which suggest that clinicians prefer features that enhance ease of use. Conversely, safety was not an important factor for physician preferences in previous comparative studies of IO systems.[13,14] This highlights the safety-related innovation of the novel IO system, as passive needle safety mechanisms are not a feature of currently available IO systems. Therefore, this study captures safety as an important factor for physician preferences and contributes to the limited information available on emergency physician preferences and values toward enhanced IO system safety features.

User preferences regarding IO systems and device features may influence the efficiency and success of an IO procedure, impacting overall patient care. This study found that emergency physicians prefer and value IO system features that enhance safety and ease of use. Thus, our findings demonstrate the importance of these design elements for the user in powered IO systems and provide the basis for studies to evaluate the clinical value of the novel IO system, its features, and their impact on practice and patient outcomes.

ACKNOWLEDGMENTS

Data analysis, writing, and editorial support were provided by Boston Strategic Partners, Inc. (funded by Becton, Dickinson and Company). Andrea McCamant (Becton, Dickinson and Company) assisted with study design and editorial review.

CONFLICT OF INTEREST

Drew Jones and Andrew Little have no conflicts of interest to disclose. Kim Alsbrooks reports current employment and stock ownership with Becton, Dickinson and Company, which manufactured the novel intraosseous system (BD Intraosseous Vascular Access System) and sponsored this study.

AUTHOR CONTRIBUTIONS

This study was conceptualized and designed by Drew Jones, Andrew Little, and Kim Alsbrooks. Drew Jones and Andrew Little recruited participants for the study. Drew Jones, Andrew Little, and Kim Alsbrooks provided substantial editorial review of the manuscript and contributed to its revisions.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Little A, Alsbrooks K, Jones D. Physician preferences associated with powered intraosseous access systems: Safety features, reliability, and ease of use. *JACEP Open*. 2022;3:e12710. https://doi.org/10.1002/emp2.12710