Bluetooth Tactical Headsets Improve The Speed of Accurate Patient Handoffs

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ABSTRACT

Background: The Committee on En Route Combat Casualty Care recently ranked the patient handoff as their fourth research priority. Bluetooth technology has been introduced to the battlefield and has the potential to improve the tactical patient handoff. The purpose of this study is to compare the traditional methods of communication used in tactical medical evacuation by Special Operations medical personnel (radio push-to-talk [PTT] and Tactical Medic Intercom System [TM-ICS]) to Bluetooth communication. **Methods:** Twenty-four simulated tactical patient handoffs were performed to compare Bluetooth and traditional methods of communication used in tactical medical evacuation. Patient scenario order and method of communication were randomized. Accuracy and time required to complete the patient handoff were determined. The study took place using a rotary-wing aircraft kept at level 2 to simulate real-world background noise. Preferred method of communication for each study participant was determined. **Results:** There were no differences in accuracy of the received patient handoffs between groups or patient handoff transmission times at the ramp of the aircraft. However, when comparing patient handoff times to the medical team within the aircraft, Bluetooth communication was significantly faster than both TM-ICS and radio PTT, while Bluetooth PTT and radio PTT were also significantly faster than TM-ICS. Bluetooth communication was ranked as the preferred method of handoff by all study participants. **Conclusion:** The study demonstrated that utilization of Bluetooth technology for patient handover results in faster handoffs compared with traditional methods without sacrificing any accuracy in a scenario with high levels of noise.

Keywords: *Tactical Combat Casualty Care; TCCC; communication; Bluetooth; medical evacuation; handoff*

Background

During the previous two decades, there has been a consistent emphasis placed on research into different elements of tactical combat casualty care (TCCC) that has resulted in decreased morbidity and mortality on the battlefield.[1,2] For example, tourniquets used on the battlefield were shown to prevent catastrophic hemorrhage, and as a result, saved lives.[3] That research subsequently led to widespread incorporation into prehospital medical training in the civilian environment. Likewise, many advances made in civilian trauma care over the previous two decades have also been incorporated into TCCC, contributing to overall improvements in morbidity and mortality on the battlefield.

One area that has received a significant amount of attention in civilian medicine, likely due to its association with adverse medical events, is the patient handoff during transfer of care.[4] Recently, the Committee on En Route Combat Casualty Care (CoERCCC), ranked it as the fourth research priority for en route combat casualty care.[5] The CoERCCC specifically stated that "improved means of providing vital patient data during handoffs is central to optimizing patient care and allocating resources on the battlefield."[5] In civilian medicine, there have been multiple studies evaluating the quality of patient handoffs at all levels, often using audio and/or video to evaluate and improve handoff processes.[6–8] The quality of the patient handoff from prehospital providers has even been shown to be associated with improved trauma team communication following the patient handoff.[9] However, until recently, this has not been a significant area of focus for combat casualty care.

Currently, the vast majority of communication on the battlefield between the medics on the ground and the medical team evacuating the patient is done through standard radio using push-to-talk (PTT) or the use of an internal communication system. These allow for a direct plugin from one headset into another, such as the Tactical Medic Intercom System (TM-ICS) (Atlantic Signal™, Topeka, Kansas; https://atlanticsignal.com/). On the current battlefield, the patient handoff is often complicated by noise due to both the combat environment and use of rotary-wing aircraft, the most common method of evacuation.[10] Recently, headsets with Bluetooth capability, Bluetooth Peltors™ (ComTac™ VI NIB Headset, PELTOR™ 3M Personal Safety Division; https://www.3m.com/3M/en_US/p/d/b5005083000/), have been fielded.

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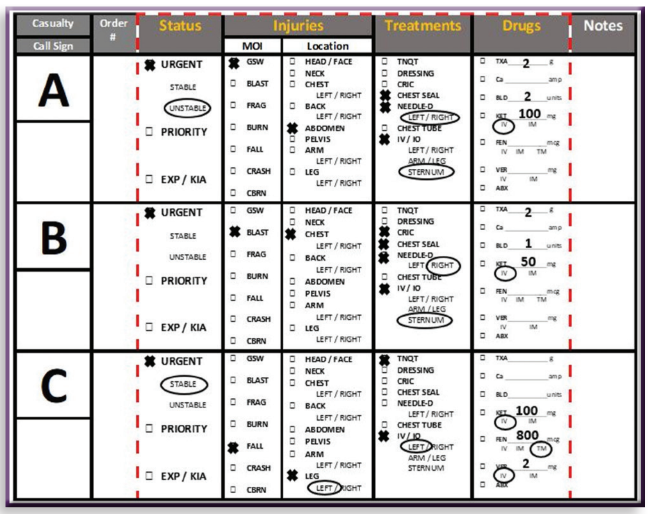
The purpose of this study was to compare the traditional methods of communication used in tactical medical evacuation by Special Operations Forces (SOF) medical personnel (radio PTT and internal communications system) to Bluetooth communication. The authors hypothesized that the use of the Bluetooth headsets would result in a faster patient handoff to the entire medical team and that it would be just as accurate as the current standard of care.

Methods

Using a standard patient casualty form utilized by an SOF medic, six patient scenarios resembling typical combat-related injuries and initial point-of-injury (POI) care were created. Each scenario included 8–10 pieces of key clinical information (Figure 1).

FIGURE 1 *Example of an SOF medic's casualty card. Three simulated casualties are shown* (**A, B,** *and* **C**), *which were three of the six scenarios used in this study.*

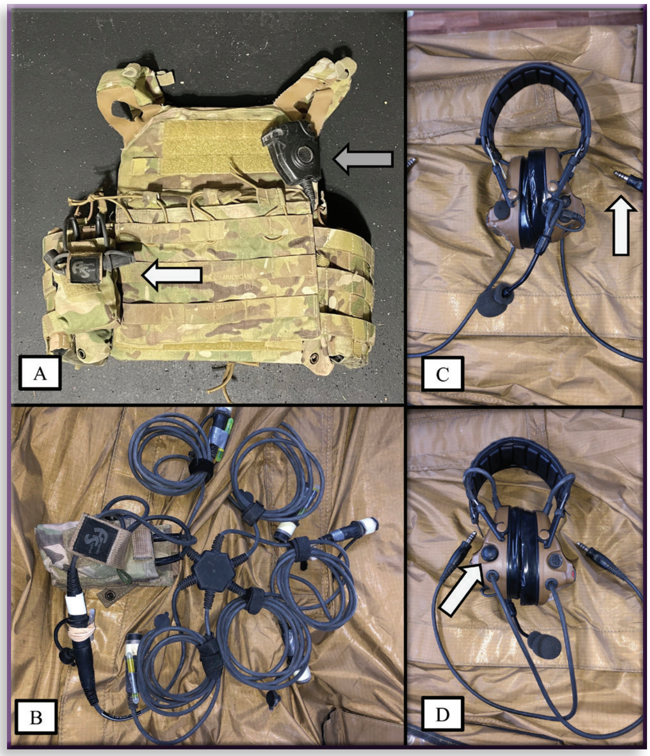


MOI = mechanism of injury; EXP/KIA = expired/killed in action; GSW = gunshot wound; CBRN = chemical, biological, radiological, and nuclear; TNQT = tourniquet; Needle-D = needle-decompression; IV/IO = intravenous/intraosseous; TXA = tranexamic acid; Ca = calcium; BLD = Blood, KET = ketamine, FEN = fentanyl; VER = Versed; ABX = antibiotics; amp = ampules; IM = intramuscular.

Typical communication for the SOF medical team is using radio PTT (Figure 2A). An alternate method of communication is the use of a TM-ICS, which allows for one-on-one communication via direct plug into the other's headset (Figure 2A). In addition, a multi-point internal communications system, allowing for the connection of up to six individuals, is also commonly used by this medical team to provide clear communication between all team members that plug into an intercom house (Figure 2B). This is ideal when multiple team members are working on a single casualty but requires unplugging when moving between multiple casualties.

Recently, Bluetooth Peltors (3M PELTOR ComTac VI NIB Tactical Headsets, https://www.3m.com/3M/en_US/p/d/b5005083000/) have been fielded in SOF environments (Figures 2C, 2D). These headsets allow communication using standard radio PTT and TC-ICS but have the added features of Bluetooth PTT and voice-operated transmission (VOX) settings. The Bluetooth PTT allows the user to transmit by pressing a button on the headset. The Bluetooth VOX setting allows voice-activated, wireless transmission. According to the manufacturer's

FIGURE 2 *Types of communication devices tested. Standard radio PTT (gray arrow) is shown in* **A** *with a single TM-ICS device (white arrow) in positions where they are commonly worn on body armor. The radio used during testing is not shown. A multi-point internal communications system is shown in* **B**, *which allows up to six individuals to connect. Finally, the Bluetooth Peltors are shown in* **C** *(front of headset) and* **D** *(back of headset). The leads that can be connected to the radio PTT and TM-ICS devices are shown in* **C**, *white arrow. The button shown in* **D**, *white arrow, allows communication with Bluetooth PTT.*

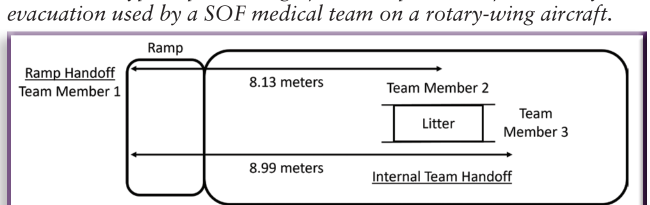


Radio PTT = radio push-to-talk; TM-ICS = tactical medic intercom system.

guidance, all connected Bluetooth headsets within a 10-meter radius should be able to receive transmissions.[11] All medical personnel involved in the study had extensive tactical medical experience that included training, real-world use, and generalized familiarity with all methods of communication tested.

Medical personnel were given a blank casualty form and were allowed to familiarize themselves with it prior to the study. During the study, team members were positioned at three locations: 1) immediately outside of the aircraft at the base of the ramp, 2) 8.13 meters inside the aircraft to the port or left side of the aircraft, and 3) 8.99 meters inside toward the nose of the aircraft at the center of the aircraft (Figure 3). This is a typical setup for casualty evacuation used by this medical team on a rotary-wing aircraft. All team members were positioned facing away from the medic who started each handoff at the ramp, eliminating any external influence.

FIGURE 3 *Typical positioning of medical personnel for casualty evacuation used by a SOF medical team on a rotary-wing aircraft.*



Timers were positioned adjacent to each team member to record the time for each patient handoff to be received. All timers and the SOF medic were in direct view of the study coordinator to trigger the start of each scenario. When the handoff was completed and the team member received what they perceived as all the relevant information, they signaled their time to stop, which was recorded. No further documentation was allowed after the time was stopped. The patient handoff was performed by the medic twice in each scenario, once at the ramp intended for the team member positioned at the base of the ramp and once at the center of the aircraft intended for the remainder of the medical team within the aircraft. There were six different patient scenarios; each was performed four times for a total of 24 simulated patient handoffs. Each method of communication was used for each scenario, and the scenario order and method of communication for each patient handoff were randomized. Finally, to simulate a real-world tactical patient handoff, the rotary-wing aircraft utilized its auxiliary power unit (APU) throughout the study. Decibel readings were collected using the National Institute for Occupational Safety and Health Sound Level Meter Application (Version 1.2.5.63, EA Lab) on a government-approved mobile device.[12,13]

All casualty forms completed by team members were reviewed, and accuracy was evaluated by determining the percentage of key information transcribed. Finally, to assess the subjective preference of the medical team participating in the study, each of the members was asked to rank their preferred methods of communication based on clarity and ease of use after the study was completed.

Statistical analysis was performed using Microsoft Excel 2018 (Microsoft Corporation, Redmond, Washington; https://www.microsoft.com/en-us/) with the Analysis ToolPak Add In. A power analysis was performed using data from an initial sample of patient handoff times using radio PTT (α = 0.05 and σ = 4.8 seconds). If the true difference in the mean time of matched pairs is 10 seconds, which was chosen as being clinically relevant, a minimum of six study pairs of patient scenarios would be required to reject the null hypothesis that this response difference is zero with a probability (power) of 0.95. Time required for completion of the patient handoff was compared separately across groups for both the ramp handoff and internal team handoff using a one-way analysis of variance (ANOVA) with alpha set at 0.05. When a difference was identified between groups, methods of communication were then compared using a single-tailed, paired *t* test for continuous variables with a Bonferroni-adjusted alpha set at 0.0125. Accuracy, as measured by the percentage of correct information transcribed, was compared between methods of communication also using an ANOVA with alpha set at 0.05.

Results

Accuracy

All methods of communication had an average accuracy of more than 90%. While the use of the Bluetooth PTT resulted in the most accurate patient handoffs, with an average accuracy of 98% (range 75%–100%), there was no significant difference between any of the groups studied when evaluating the accuracy of the transmission received (p=.25 ANOVA) (Table 1).

TABLE 1 *Accuracy Group Comparison Statistical Analysis Method of Communication*

Method of communication	Accuracy, %, mean (range)	Group comparison statistical analysis, ANOVA
Radio push-to-talk	92.61 (70–100)	p=.25
Tactical medic intercom system	95.89 (78–100)	
Bluetooth push-to-talk	98.00 (75–100)	
Bluetooth voice-operated transmission	93.72 (60–100)	

ANOVA = analysis of variance.

Time

Ramp Handoff

The average Bluetooth PTT resulted in the fastest patient handoff (mean 17.81 [range 13.31–25.54] seconds), and the slowest occurred when using the TM-ICS (mean 20.13 [range 16.20–30.18] seconds), but there was no significant difference between ramp handoff times (p=.86 ANOVA) (Table 2).

TABLE 2 *Comparison of Handoff Times at both the Ramp and Internal Team*

Method of communication	Handoff times (sec) ramp (team member 1)	Group comparison statistical analysis, ANOVA
Radio PTT	19.76	p=.86
TC-ICS	20.13	
Bluetooth PTT	17.81	
Bluetooth VOX	18.97	

Method of communication	Handoff times (sec) internal team (team members 2 and 3)	ANOVA	Radio PTT	TC-ICS	Bluetooth PTT	Bluetooth VOX
Radio PTT	31.31	p<.001		p<.01*	p<.03	p<.01*
TC-ICS	41.33		p<.01*		p<.001*	p<.001*
Bluetooth PTT	22.44		p<.03	p<.001*		p<.47
Bluetooth VOX	22.19		p<.01*	p<.001*	p<.47	

*Denotes statistical significance (single-tailed, paired t test with Bonferroni correction; α = 0.0125).

ANOVA = analysis of variance; Bluetooth VOX = Bluetooth voice operated transmission ; PTT = push-to-talk; TC-ICS = tactical medic intercom system.

Internal Team Handoff

The fastest internal team handoff occurred with both Bluetooth methods of communication (Bluetooth VOX, mean 22.19 [range 12.13–30.98] seconds; and Bluetooth PTT, mean 22.44 [range 14.32–53.69] seconds). Bluetooth VOX, Bluetooth PTT, and radio PTT (mean 31.31 [range 16.36–54.28] seconds) were significantly faster than TM-ICS (mean 41.33 [range 30.21–46.70] seconds; $p<.001$ ANOVA; $p<.001$ Bluetooth VOX vs. TM-ICS, $p<.001$ Bluetooth PTT vs. TM-ICS, $p<.01$ radio PTT vs. TM-ICS, Bonferroni) (Table 2). Bluetooth VOX was also significantly faster than radio PTT ($p<.001$ ANOVA; $p<.01$ Bluetooth VOX vs. radio PTT, Bonferroni) (Table 2).

Patient Handoff Preference

A Bluetooth method of communication was preferred by all study participants based on clarity and ease of use. Bluetooth PTT was the preferred method (75% ranked first, 25% ranked second), with Bluetooth VOX being the next preferred method of communication (25% ranked first, 50% ranked second) (Table 3).

TABLE 3 *Preference of Communication Method for a Patient Handoff*

Preference rank	Method of communication, % of participants			
	Radio PTT	TC-ICS	Bluetooth PTT	Bluetooth VOX
1st	0	0	75	25
2nd	0	25	25	50
3rd	50	50	0	0
4th	50	25	0	25

Bluetooth VOX = Bluetooth voice operated transmission; PTT = push-to-talk; TC-ICS = tactical medic intercom.

Background Noise

The average background noise with the rotary-wing aircraft APU on level 2 was higher when measured at the ramp (mean 116 [range 113.7–118.9]dB) compared with the average background noise inside the aircraft where the surgical team was positioned (mean 97.8 [range 95.7–100.5]dB).

Discussion

This study demonstrated that the use of Bluetooth technology for patient handoff communication resulted in faster patient handoffs in a scenario involving a two-stage handoff when compared with conventional methods of communication (radio PTT or TM-ICS) without sacrificing accuracy during high levels of steady state noise. When considering single-stage handoffs occurring immediately outside of the aircraft, although both Bluetooth groups resulted in slightly faster patient handoff times, the difference in time was not significant. The participants—medical providers experienced in using all four methods of communication across the range of medical operations—ranked Bluetooth patient handoffs, specifically Bluetooth PTT, as the preferred method of communication because of the overall clarity of transmission.

As the delivery of medicine and trauma care continues to improve, all aspects of care across the entire continuum of care serve as an opportunity for critical study. The patient handoff has recently received significant attention because of its association with adverse medical events and perceived opportunities for improvement.[4,14,15] When evaluating the quality of patient handoffs of critically ill and injured patients that were either directly observed or recorded with subsequent review, Goldberg et al. found very poor quality in patient handoffs from emergency medical services (EMS) to emergency medicine physicians.[8] Similarly, Benner et al. found that EMS patient handoffs included only 44% of pertinent data, with only 51% of physicians being satisfied with the overall patient handoff.[16]

There is evidence that the quality of the patient handoff improves the delivery of care to the trauma patient. When the MIST report (Mechanism, Injuries, Signs (vitals), and Treatments) was instituted as standard practice for EMS transporting patients to a single level 1 trauma center, Maddry et al. found a correlation with improved inpatient records reporting accurate prehospital interventions to include fluids administered and vitals.[7] Ultimately, this resulted in an overall improvement in the patient handoff experience.[6] Similarly, an analysis of videos obtained during patient handoffs by EMS found a correlation between EMS MIST report completeness and high performance by the receiving trauma team.[9]

These data are extremely relevant for trauma program medical directors, both in the military and in civilian practice, and reinforce the importance of standardized communication during the patient handoff. This can include the format in which the information is delivered, so the receiving team can anticipate and respond appropriately to optimize care. This also has specific relevance for the small surgical teams that are far forward in combat or austere environments. While some of these surgical teams have extensive training in communication in the tactical or austere environment, which includes demonstrating proficiency in the various methods of communication, the majority do not. This lack of training could impact patient care in a sound-restrictive environment or one with significant background noise.

One potential barrier to an optimal patient handoff is background noise in the emergency department. In fact, recommendations have even been made to measure decibel levels frequently, ensuring they remain below a certain threshold in common patient handoff areas to improve the overall quality of the handoff.[4] Compared with a loud emergency room, there are more significant obstacles in obtaining a quality patient handoff in the combat environment. For example, during the recent conflicts in Afghanistan and Iraq, over 85% of combat casualties were evacuated from POI via aircraft, with rotary-wing aircraft being the most common mode of transportation.[10] It is common practice for all medics in the field and rotary-wing aircraft personnel to wear hearing protection. However, it is important that the hearing protection worn does not provide a barrier to communication. This is especially important when it is already known that military rotary-wing pilots have reported that background noise is a common problem in consistent radio communication.[17]

It is important to understand the reasons why the use of Bluetooth communication, both Bluetooth PTT and Bluetooth VOX, on the fielded headsets were the preferred method of communication during the patient handoff. The common reason provided was clarity of communication, specifically with Bluetooth PTT, but there are several additional reasons for the preferences described that must also be noted. First, the Bluetooth VOX setting allows for completely hands-free communication, which can be extremely beneficial during care of the patient. Perhaps even more important is that the Bluetooth headsets can allow communication with each other without the need for both personnel to be on the same radio channel. This is extremely beneficial in a patient evacuation scenario, as the medic evacuating the patient from POI typically will have their radio set to a different frequency to communicate with personnel on the ground, rather than the medical team receiving the handoff who would typically have their own internal radio channel for communication. In other words, using Bluetooth communication removes some potential barriers of communication between different levels of care, allowing the medical teams to provide care more efficiently.

Despite these advantages of Bluetooth communications, there are both limitations and advantages to the technology when compared with the other commonly used methods tested. If team members are beyond the distance of the communication "bubble," they likely will not receive the transmissions when using the Bluetooth settings. According to the manufacturer's recommendations, this bubble has a 10-meter radius, with 3–5 meters as the optimal radius for communication, which extends beyond the typical area of a group taking care of a single casualty.[11] Furthermore, while standard radio PTT can be used with an unlimited number of people within range on the same channel, the Bluetooth headsets tested are limited to transmission among four people within the connected group. However, any number of personnel within the 10-meter bubble should be able to receive all transmissions.[11] While this was not a factor in the testing performed because of the size of the medical team, it could pose a limitation in communication if larger medical teams are working together using the Bluetooth headsets. However, it is also important to note that if the Bluetooth function is not working, the headsets can still function in their default mode using radio PTT or by direct plugin with TM-ICS. Although TM-ICS resulted in the slowest simulated patient handoff times, it does have the benefit of allowing anyone wearing a headset with an appropriate drop-down lead (NATO J11) to communicate via direct connection, without the need for being on the same radio frequency or also having Bluetooth-compatible headsets. Finally, the battery life is also shorter compared with non-Bluetooth PELTOR headsets, which could be a factor during sustained operations or the prolonged field care environment.[18]

Limitations

This study has several limitations. The study design was set up without allowing for the opportunity for closed-loop communication. While closed-loop communication would have likely improved accuracy, albeit while sacrificing time, the decision was made to only allow one-way transmission during the study to minimize potential confounding variables. During a medical evacuation from POI, it is likely that the rotary-wing aircraft would be at level 1 (blades spinning) while the study was conducted at level 2 (auxiliary power unit on). This was done for safety reasons during study execution. While not assessed during the study, the noise level difference between level 1 and level 2 is approximately 5–10 decibels and likely would have had a similar effect across all methods of communication studied. Finally, the casualty cards used by the SOF medic studied do not follow the typical MIST report framework, which could result in the medical team being unfamiliar with the format of the patient handoff, resulting in both a decrease in accuracy and an increase in time required to complete the patient handoff. However, the medical team members train extensively with the ground force medics and have a similar familiarity with their preferred patient handoff delivery compared with other more common patient handoffs, such as the MIST report.

Conclusion

One of the benefits of the SOF community is the use of continual cross-training and simulation to improve team communication and cohesiveness among all levels of care on the battlefield, from POI to damage control surgery, with continual efforts being made to optimize the delivery of care and subsequent outcomes for the combat-injured. This study demonstrated that Bluetooth headsets used by medical providers during a simulated patient handoff to a SOF medical team resulted in faster patient handoffs without sacrificing accuracy, thus allowing for faster time to initiation of further medical treatment. At the conclusion of the study, Bluetooth communication was also rated as the preferred method of communication by all study participants.

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Author Contributions

DJS conducted the literature search. DJS, CM, and JAP designed the study. All authors were involved in the data collection. DJS and AN analyzed the data. DJS interpreted the data. DJS wrote the manuscript, and CM, MB, AN, CP, HS, JK, and JAP critically revised it.

Disclosures

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