Simplified Method for Rapid Field Assessment of Visual Acuity by First Responders After Ocular Injury

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ABSTRACT Objective: Initial visual acuity after ocular injury is an important measure, as it is an accurate predictor of final visual outcome and gives a rapid estimation of the overall severity of the injury, thereby aiding evacuation prioritization. We devised a simple method for rapidly assessing visual acuity in the field without having to rely on formal screening cards. Methods: Using common objects, icons, and text found in the injury zone – for example, common military name tapes, rank insignias, patches, emblems, and helmet camouflage bands, which will be known collectively as the Army Combat Optotypes (ACOs) – a Snellen-equivalent method of assessing visual acuity was devised and correlated to the ocular trauma score (OTS). Results: Ability to read the ACOs at 2, 3, and 5 ft correlates with acuities in the range from 20/20 to 20/400. Identification of ACOs with visual acuity of 20/50 and 20/200 approximates important inflection points of severity for the OTS. Conclusion: Accurately assessing visual acuity in the field after ocular injury provides essential information but does not require sophisticated screening equipment. Pertinent and accurate acuities can be rapidly estimated using commonly available text or graphical icons such as standard name tapes, patches, and rank insignias.

INTRODUCTION

Ocular injuries contribute significantly to morbidity for U.S. service members. The number of ocular injuries, although on the decline, was 13% of all injuries during the conflict Operations Iraqi and Enduring Freedom and has more recently fallen to 6%,[1–3] which is likely due to the mandatory use of combat eye protection.[3] Initial visual acuity is an important measure in predicting final visual outcome as seen with the ocular trauma score.[4] Early assessment of visual acuity is a component of both the Tactical Combat Casualty Care (TC3) guidelines and the Joint Trauma System Clinical Practice Guideline (JTS CPG) because visual acuity determines severity of ocular injury.[5,6] Point of injury circumstances reasonably preclude formal vision testing by traditional methods such as Snellen vision testing or the use of a Rosenbaum pocket card. Life-threatening injuries requiring early intubation close to the point of contact can make initial visual assessment exceedingly difficult. The first opportunity for visual assessment may come days to weeks after injury and often post-operatively.

Traditionally, visual assessment is determined by trained first responders with standardized eye charts to include Snellen eye chart, the Early Treatment of Diabetic Retinopathy Study optotype (ETDRS), Rosenbaum pocket card, Landolt "C," tumbling "E," HOTV, Allen figures, and the Lea chart for preschool children.[7,8] Trauma in urban conditions have the benefit of using acceptable alternatives for assessing visual acuity when Snellen or Rosenbaum charts are not available; for example, newspaper print, lettering on medical equipment, or the use of a hospital employee name tag.[9] In the austere environment, the first responder may not be a trained medical professional such as a medic. In the heat of battle, it may be a battle buddy who responds initially and these individuals usually do not carry extra medical equipment other than an Individual First Aid Kit, which does not contain a way to measure visual acuity. Additionally, in combat, the utility of an eye chart is impractical and the speed at which a soldier's injuries are assessed and the decision for evacuation must be rapid. On the other hand, simply asking "Is your vision ok?" or "can you see my fingers" can lead to inaccurate underestimates of visual potential and therefore lead to a change in management of the patient.

The ocular trauma score (OTS) was developed to predict visual prognosis after serious ocular injury. Of the numerous variables required for predicting final visual outcome, initial visual acuity is the most important; other objective findings to include globe rupture, endophthalmitis, perforating injury, retinal detachment, and afferent pupillary defect also contribute to estimating final visual acuity. The importance of the OTS was initially described for civilian trauma to assist the ophthalmologist

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in counseling the patient regarding management and rehabilitation. The validity of the OTS has been confirmed by recent studies, reinforcing the usefulness and accuracy of the score.[10–15]

The OTS assigned raw points to various ranges of visual acuity. On inspection of those ranges, there appears to be inflection points where visual prognosis seems to split; these points are 20/50 and 20/200. Therefore, if presenting visual acuity was better than 20/50, then there was a greater than 94% chance of retaining vision of 20/50 or better. If presenting visual acuity was worse than 20/200, the patient would have between a 1% and 41% chance of visual acuity measuring better than 20/50; that is, most individuals would end up with vision 20/200 or less.[4,8,11–13] With the recognition of these inflection points and the need to take expedient visual acuities in the field, the goal was to identify common objects, icons, and text found in the injury zone that is associated with 20/50 and 20/200.

We embarked on devising a simple method for rapidly assessing visual acuity in the field without having to rely on formal screening cards, which would provide a more accurate and reliable assessment than simply counting fingers.

METHODS

The battle uniform and equipment provided to the U.S. Army was inspected and analyzed to identify common objects, icons, and text that could be correlated with a Snellen-equivalent visual acuity. These include common military name tapes, rank insignias, patches, emblems, and helmet camouflage bands, which will be classified as the Army Combat Optotype (ACO). A standardized chart was devised based on the current use and knowledge of the Snellen optotype. The ACOs identified were measured and correlated with known equivalent visual acuities (see calculations in Supplementary data, Appendix A). The dimension and sizes of various name tapes, rank insignias, patches, emblems, and lettering on the Kevlar camouflage bands were determined and correlated with visual acuities ranging from 20/20 to 20/400 at 2, 3, and 5 ft.

RESULTS

The measurements of the various ACOs were taken and are as follows. The standard subdued flag worn on the right arm measures 4.5 cm in height by 8 cm in length, the stripes are 3 mm in width, the field of stars measures 2 cm by 3.5 cm, and the widest portion of an individual star measures 2 mm in width (Fig. 1). The name tapes with the words "U.S. ARMY" and the soldier's last name are worn on the left and right chest, respectively. They measure 2.54 cm in height by 12.7 cm in length and the letters are 18 mm in height (Fig. 2). The lettering on the elastic band worn on the Kevlar helmet is often added to convey blood type and the soldier's last four digits of his social security number. Kevlar helmet band measures 8 mm in height by 12 mm in length with the letters measuring 6.5 mm in height (Fig. 3). The rank insignia worn on the center of the soldier's chest measure 5 cm by 5 cm. The officer rank insignia for Lieutenant and Captain have bars that measure 25 mm in height and 9 mm in width. The Major's (MAJ) and Lieutenant Colonel (LTC) insignia measure 25 mm by 25 mm. The difference between the MAJ and LTC insignia is the color, gold for MAJ and black for LTC. The Enlisted and noncommissioned officer insignia are composed of a variable number of chevrons. Each individual chevron measures 2 mm in width and the spacing between the chevrons measures 1 mm (Fig. 4).

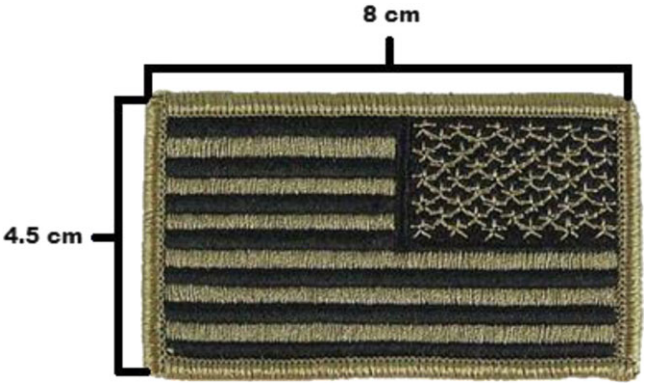

FIGURE 1. The subdued flag is worn on the soldier's right arm. It measures 4.5 cm in height by 8.0 cm in width. The field of stars measures 2 cm in height by 3.5 cm in width. Each individual star measures 2 mm at the widest portion. The stripes on the flag measure 3 mm in width.

FIGURE 2. The name tapes are worn on the right and left chest. They measure 2.54 cm in height and 12.7 cm in length. The letters measure 18 mm in height.

FIGURE 3. The band worn on the Kevlar helmet consists of a series of letters and numbers, usually the soldier's initials and last four numbers of their social security number along with the soldier's blood type. The Kevlar band measures 8 mm in height by 12 mm in length and the letters measure 6.5 mm in height.

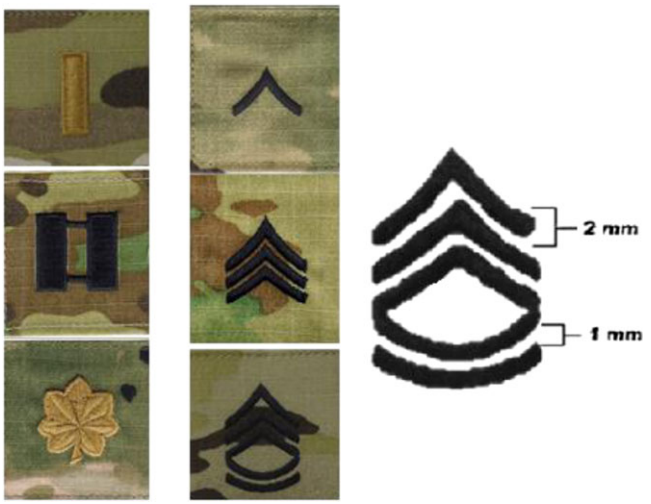

FIGURE 4. The rank insignia worn on the center of the soldier's chest measure 5 cm by 5 cm. The officer rank insignia for Lieutenant (top left) and Captain (middle left) have bars that measure 25 mm in height and 9 mm in width. The Major insignia (bottom left) measure 25 mm by 25 mm. The Enlisted insignia are composed of a variable number of chevrons. Each individual chevron measures 2 mm in width and the spacing between the chevrons measures 1 mm.

Mathematical Snellen-equivalent visual acuities were calculated for distances of 2, 3, and 5 ft as these distances are consistent with normal working distance from the battle buddy or medic to the injured soldier. If the medic is assisting with an injury on the upper extremity, he would be about 2–3 ft away versus the lower extremity, which is 3–5 ft in distance. At 2 ft, the Snellen equivalent of 20/50 visual acuity correlates with a star on the flag; the stripes on the flag correlated with 20/70. The lettering on the Kevlar name tape correlated with 20/150 and the lettering on the name tapes on the front of the uniform represents 20/400 vision (Table I). At 3 ft, the stars on the flag correlated with vision better than 20/40; the stripes on the flag correlated with 20/50; the Kevlar name tapes and ACU name tapes correlated with 20/100 and 20/250, respectively (Table II). Finally, at 5 ft, we were able to obtain a wider range of visual acuities as follows: the chevron and stars on the flag equal 20/20 vision; the stripes on the flag are 20/30; the lettering on the Kevlar name tapes are 20/70; and the ACU name tape are 20/200 (Table III).

DISCUSSION

Currently, there is no effective, efficient, and accurate means to estimate initial visual acuity in the austere environment at the point of injury. Initial visual acuity is necessary for determining prognostic outcomes as proposed by the OTS for which the validity and accuracy have been confirmed by current and ongoing research, which can help in patient triage and ultimately evacuation prioritization.[10–15] The use of near cards or other forms of formal visual acuity testing is not practical as soldiers in the heat of battle do not have the access or the time to use a standardized eye chart to evaluate visual acuity especially in the

TABLE I. The Exact Size an Object Has to be Correlated with Snellen Visual Acuity at 2 ft for a Letter that Subtends 5 min of Arc. The Army Combat Optotype Equivalent Is a Rough Estimate of the Exact Measurement in Millimeters

Near at 2 ft	Size of Object (mm)	ACO
20/20	0.8866	
20/25	1.10825	
20/30	1.3299	
20/40	1.7732	
20/50	2.2165	Star on the flag
20/60	2.6598	
20/70	3.1031	Stripes on flag
20/80	3.5464	
20/90	3.9897	
20/100	4.433	
20/150	6.6495	Kevlar name band
20/200	8.866	
20/250	11.0825	
20/400	17.732	Name tape

TABLE II. The Exact Size an Object that Has to be Correlated with Snellen Visual Acuity at 3 ft for a Letter that Subtends 5 min of Arc. The Army Combat Optotype (ACO) Equivalent Is a Rough Estimate of the Exact Measurement in Millimeters

Near at 3 ft	Size of Object (mm)	ACO
20/20	1.3299	
20/25	1.662375	
20/30	2.6598	
20/40	2.6598	Star on the flag
20/50	3.32475	Stripes on flag
20/60	3.9897	
20/70	4.65465	
20/80	5.3196	
20/90	5.98455	
20/100	6.6495	Kevlar name band
20/150	9.97425	
20/200	13.299	
20/250	16.62375	Name tapes
20/400	26.598	

TABLE III. The Exact Size an Object Has to be Correlated with Snellen Visual Acuity at 5 ft for a Letter that Subtends 5 min of Arc. The Army Combat Optotype (ACO) Equivalent Is a Rough Estimate of the Exact Measurement in Millimeters

Near at 5 ft	Size of Object (mm)	ACO
20/20	2.2165	Chevron, Star on the flag
20/25	2.770625	
20/30	3.32475	Stripes on the flag
20/40	4.433	
20/50	5.54125	
20/60	6.6495	
20/70	7.75775	Kevlar name tape
20/80	8.866	
20/90	9.97425	
20/100	11.0825	
20/150	16.62375	
20/200	22.165	Name tape
20/250	27.70625	
20/400	44.33	

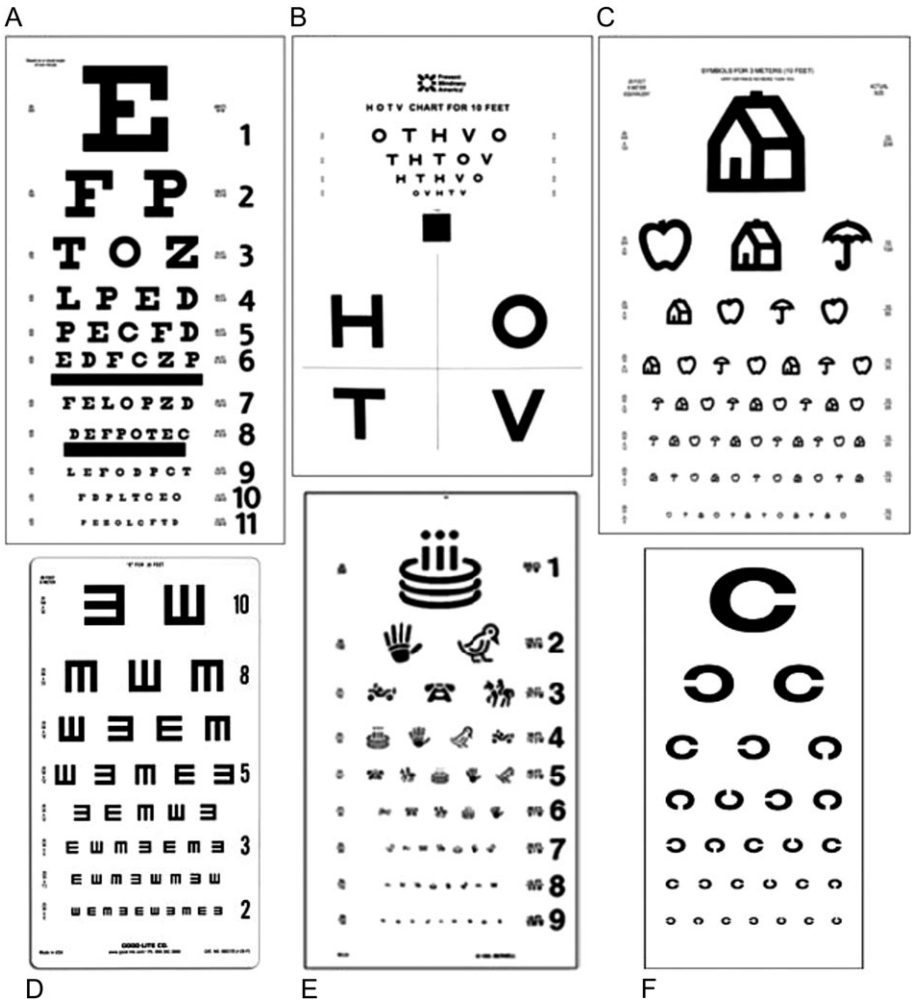

FIGURE 5. Examples of visual acuity charts. (A) Snellen, (B) HOTV, (C) Lea, (D) Tumbling "E", (E) Allen, and (F) Landolt C.

setting of potentially life-threatening injuries. A delay, which can be days to weeks after the injury, in the assessment of visual acuity has not been studied or correlated with final visual outcome, which makes predicting final visual prognosis difficult.

The present study used the Army Combat Optotypes as a means for determining visual acuity. Snellen acuity is based on the ability to discern a standardized optotype and the science behind the construction of the Snellen letters was extrapolated and applied to the U.S. Army uniform. Standard vision is the ability to recognize an object with more than two contours; for example, the big "E" on the Snellen vision chart consists of five contours. At a distance of 20 ft, the average human eye can discern 5 min of arc, which equates to a specific letter height.[8,9,16] Calibrated letters are constructed so that the stroke width and gap width of the letter are each equal to 1 min of arc with a total letter height corresponding to 5 min of arc (Supplementary data, Appendix A). In addition to Snellen visual acuity, there are other standardized vision charts to include, the ETDRS, Landolt "C," Tumbling "E," HOTV chart for preschool children, and the pictorial optotpyes including both the Allen figures and the Lea test for preschool children (Fig. 5), which follow the same principles. The pictorial optotype is also a standardized way to assess vision is preverbal, nonverbal, and foreign language speakers, which have been accurately correlated with traditional numbers or letters.[8,15] The graphics and symbols on the U.S. Army uniform are for the most part standardized[17] and geometrically shaped, giving them two or more contours allowing for a certain degree of visual resolution similar to that of the Allen figures.

The OTS inflection points, 20/50 and 20/200, which give the most helpful information, were correlated with the ACOs. We found that the stars on the subdued flag and the lettering on the Kevlar bands equal 20/50 and 20/200, respectively, at 2 ft. The stripes on the flag and the lettering on the Kevlar bands correlate with 20/50 and 20/150, respectively, at 3 ft. Finally, at 5 ft, the stripes on the flag equated to 20/30, the lettering on the Kevlar name tape was 20/70, and the ACU name tapes correlated with 20/200 vision.

The distances of 2, 3, and 5 ft were chosen as the routine working distance for the first responder is within this range. At 2 and 3 ft, visual assessment can be obtained while simultaneously evaluating the upper extremities down to the torso. At 5 ft, visual acuity can be assessed while evaluating the soldier's

lower extremity up to torso. In clinical practice, evaluation of visual acuity should be done with both eyes together and individually. In the heat of battle, it is appropriate to obtain monocular acuities for the sake of time. Occlusion of one eye should be done with caution, as manipulation of certain ocular injuries (i.e., ruptured globe) should be avoided. Covering the eye should be done without touching the face, by holding an occluder (i.e., a hand or other opaque object) in front of the eye. Documentation of visual acuity can be as simple as stating the ACO the patient can identify at the specified distance. For example, a patient's visual acuity can be written as "Kevlar band at 3 feet," which is known to be 20/150 vision. For ACOs that are easily recognizable, such as the subdued flag, specific instructions should be given to truly evaluate their ability to see the stars and stripes. The examiner can ask if the patient can see each individual star or stripe, which should not be confused for stating that they can identify the entirety of the subdued flag.

One limitation to the study is that Snellen acuity is based on the ability to discern specific standardized optotypes. Letters used outside the pre-selected calibrated optotypes are technically not valid for acuity testing. Although, it is well known that non-Snellen surrogates have been long accepted and since the ACOs are mathematical equivalents, more studies are required to validate utility. A second limitation includes the potential difficulty with contrast sensitivity. The ACOs are not black letters on a white background or white letters on a black background like the high-contrast Snellen-equivalent letters, which could make identifying the object more difficult than the traditional Snellen optotype particularly in dim environments; therefore, these screening acuities may actually be underestimates of true visual acuity. Nevertheless, being able to evaluate whether the visual acuity is on the chart versus off the chart is the primary consideration. Further testing should be completed in a controlled environment to compare patients who have a known Snellen visual acuity against the Army Combat Optotypes identified in the study and attempts should be made to quantify and adjust the visual acuity to the level of reduced contrast. In addition, as the Army Combat Uniform changes so will the accuracy of the optotypes and a re-calibration will need to be completed with each uniform adjustment. Finally, this study only evaluated the Army Combat Uniform and the Air Force, Navy, and Marine equivalents can be extrapolated from the present study.

Rapid assessment of visual acuity in the field does not require sophisticated equipment and can be more accurate than just "counting fingers" or determining "hand motions." Obtaining these visual acuities at the point of injury can assist with triage and evacuation prioritization. The need for obtaining a specific "best" acuity is not required as illustrated by the inflection points in the OTS. Knowing that the visual acuity is better than 20/50 or worse than 20/200 is sufficient and will allow for appropriate triage and management to be undertaken.

SUPPLEMENTARY DATA

Supplementary data are available at *Military Medicine* online.

PRESENTATIONS

Presented poster at the 2016 Military Health System Research Symposium, Kissimmee, FL (abstract number: MHSRS-16-0272).

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