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ORIGINAL ARTICLE

NEW TRIAGE SYSTEM USING DIGITIZED INFORMATION ENTERED VIA A DIGITAL PEN

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Abstract ***Objectives:*** We have created a new triage tag using the Anoto Live Digital Pen (Anoto K.K., Tokyo, Japan). We introduced this new triage tag and assessed whether this new triage system using digitized information entered via a digital pen can be used as an information-gathering tool during disasters.

Methods: We assessed our new triage tag by sending a PC digital data, which was useful and accurately transmitted in tabletop and field studies. In the field study, we assessed the accuracy of three categories of digitized data: check boxes, numeric characters, and letter characters.

Results: We could collect data from 39 simulated patients in the field study. The simulated patients' information entered on the handwritten triage tag was quickly digitized and transmitted, and a chronologic list could be made. Assessment of the accuracy of the digitized data for each category was check box, 100.0%; numeric characters, 68.2%; and letter characters, 44.0%.

Conclusions: This new triage system using digitized information entered via a digital pen has some problems with the recognition of letter and numeric characters. However, it almost exactly digitized the data, and it may be a useful device during disasters in the future.

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Key words: chronologic list; digital pen; triage tag; disaster; information tool.

Introduction

Triage is important in determining the priority of treatment for many patients injured in a disaster[1,2]. Because the patient's information entered on triage tags and the chronologic list generated from the data gathered from each section of the tag are done manually, the process is complicated, and accuracy and rapidity cannot be guaranteed[3]. A color-coded tagging method to categorize disaster victims in the field, such as the START method, has been the most widely recognized and used system in the world. Furthermore, in the United States, a new triage system called the Wireless Internet Information System for Medical Response in Disasters (WIISARD) is currently under development that can be used as a personal digital assistant system and digital information for use at mass gatherings and disasters and which provides patient data and information that can be available anywhere[4-8]. Also, Spain introduced a mobile communication tool and network for use in disasters[9].

Digital pens can translate contents handwritten in proper form into digital data and transfer them to distant areas by smartphone using the Bluetooth service or an Internet connection. Recently, digital pens have been used for customer management and the marking of examinations and prehospital information sheets[10-12]. We had the novel idea to create a new triage tag that could use the Anoto Live Digital Pen (Anoto K.K., Tokyo, Japan). We introduced the new triage tag and system and assessed whether this new triage system using digitized information

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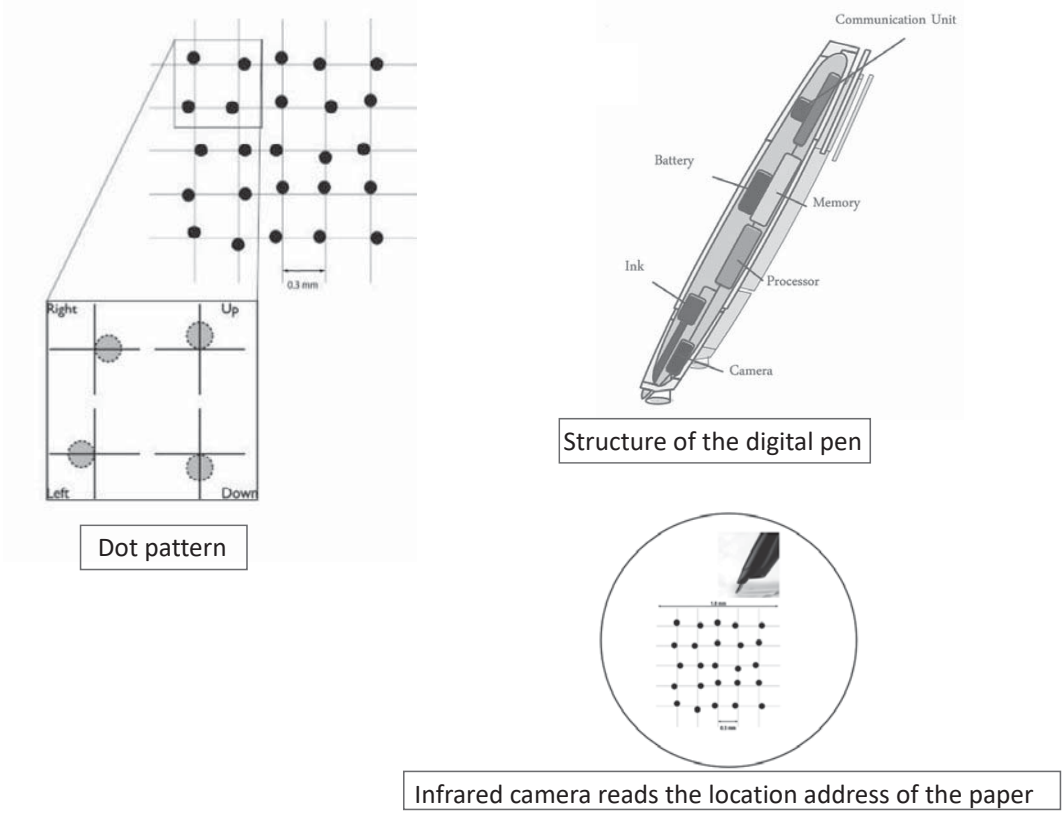

Figure 1 Schematic of the Anoto Live Digital Pen and dot-reading pattern.

entered via a digital pen could be used as an information-gathering tool during disasters.

Methods

Digital pen

Digitization of written data is performed by several methods, such as ultrasonographic, electrostatic capacitance, electromagnetic, and pressure-sensitive methods. These methods present several problems, such as prohibition of use in certain areas, inaccuracy of the data, and the need for electrical power. The Anoto company's method can digitize data using only paper and the pen, and this digital pen does not require an external source of electrical power. Anoto's digital pen uses a 6×6 dot pattern laid out on the paper for recognition of written data[13]. The digital pen uses an infrared camera to read the location address of the paper based on the dot locations. These data are then compressed and encoded. The pen itself can perform the functions of information gathering and of monitoring its status, including the location of the written data on the paper; the speed, pressure, and time of writing of the data, and the inclination and rotation of the pen. The written data can then be collected and transferred to another location by Bluetooth or USB. The collected data of about 400 patients can also be stored on the pen itself. The pen works with a rechargeable battery that can be recharged via a USB cable connected to a personal computer (PC). The pen can work for 8 hours on a single electrical charge and requires 2.5 hours to fully recharge the battery.

Triage tag

We developed a new triage tag printed on paper containing the invisible dot pattern re-

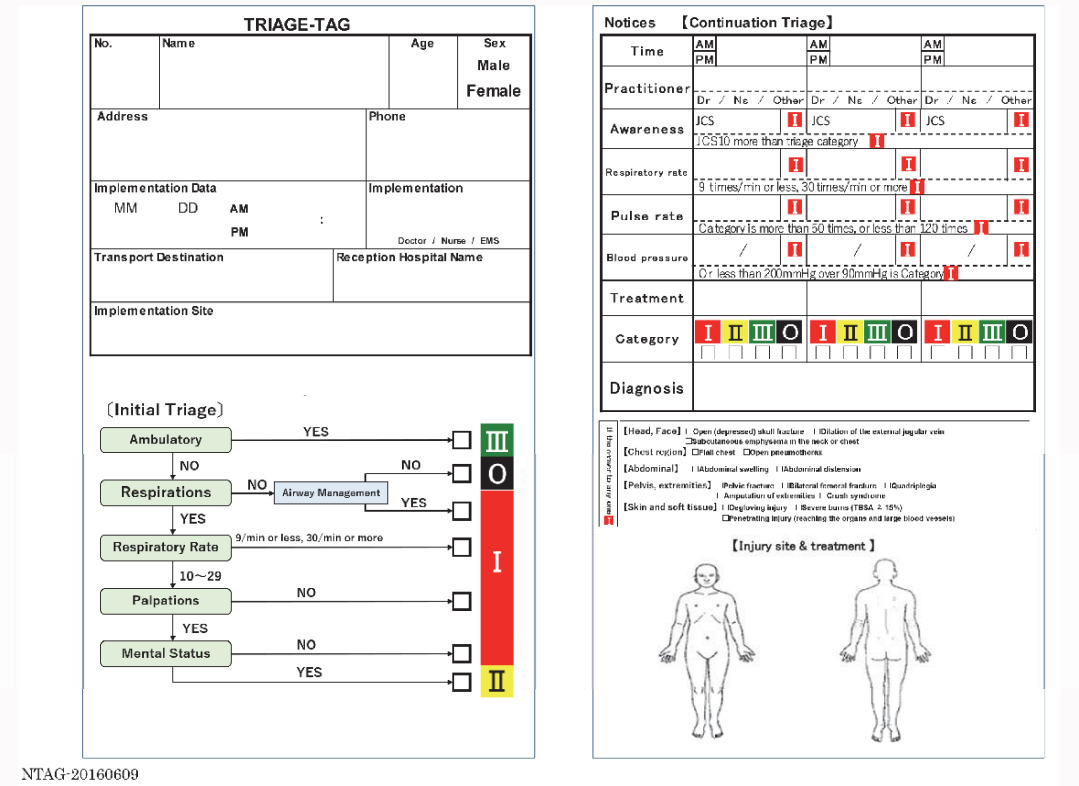

Figure 2 New triage tag.

quired for use with the digital pen. This tag uses a new format, which is a form of the Simple Triage and Rapid Treatment (START) method. Data written on the tag is converted to digital data using a computerized character recognition program. We have used many check boxes on this tag to make recognition of the written data easier. For easy assessment by all evaluators, we also list numeric values on the START evaluation sheet so they can easily evaluate the severity category.

Information collection system

The digital data is sent by Bluetooth to the PC, which displays the contents written on the Triage tag. Also, the written contents are analyzed by a character recognition program, converted, and summarized in a data table by category. The table lists the name, age, sex, address, telephone number, severity category (red, yellow, green, or black), diagnosis, name of the triage operator, and destination medical institution of each patient triaged. Furthermore, we developed the system to collect and format the triage information in a chronologic list.

Tabletop and field studies

We first performed a tabletop study to assess the transmission of the digital data from our new triage tag to a PC and found it to be useful and accurate. This study was carried out by medical students at Hirosaki University. We evaluated the accuracy and speed at which the data written on the new triage tag was transferred to the PC and displayed on the monitor screen.

Then, in the field study, we used the digital pens and triage tags during disaster training exercises performed in Hirosaki city on September 21, 2016 and on September 22, 2017. These studies included in total 157 fire department staff, along with 7 other fire department staff and 12 triage practitioners located at the countermeasures

No	Name	Age	Sex	Diagnosis	Classification	Category	Transport EMS	Destination Hospital	Triage Locatioon
12	RIKA ITOU	18	Female		Mental Status YES	2	ambulance	Hirosaki University Hospital	Iwaki Ocean Center
8	TUTOMU AKITA	29	Male		Mental Status YES	2	ambulance	Hirosaki University Hospital	Iwaki Ocean Center
24	TOMOKA TERAYAMA	8	Female		Move The Walking YES	3	ambulance		Iwaki Ocean Center
7	TAKAAKI OOTA	38	Male		Mental Status YES	2	ambulance	National Hirosaki Hospital	Iwaki Ocean Center
	KAKERU MUKAI	42	Female		Move The Walking YES	3	bus		Iwaki Ocean Center
9	SOKA KAKIZAKI	75	Female		Mental Status YES	2	ambulance	National Hirosaki Hospital	Outdoors
17	NAMI TODA	28	Female		Move The Walking YES	3	bus		Outdoors
3	RYUU KIDA	36	Male	Abominal Swelling	Respiratory Rate 9min or less,30min or more	1	ambulance	Hirosaki University Hospital	Outdoors
1	MADOKA FUWA	8	Male	Open Skull Fracture	Respiratory Rate 9min or less,30min or more	1	ambulance	Hirosaki University Hospital	Iwaki Ocean Center
4	RYO KIDA	51	Male	Open Pneumothorax	Mental Status NO	1	ambulance	Hirosaki University Hospital	Iwaki Ocean Center
20	ASUKA SERA	39	Female		Move The Walking YES	3	ambulance		Iwaki Ocean Center
2	NAOYA KIKUCHI	40	Male	Rib fracture	Respiratory Rate 9min or less,30min or more	1	ambulance	Hirosaki University Hospital	Iwaki Ocean Center
19	MAKI KIDOGUCHI	37	Female		Move The Walking YES	3	bus		Iwaki Ocean Center
10	KANA GOTOU	31	Female	Suspected right ankle fracture	Mental Status YES	2	ambulance	National Hirosaki Hospital	Iwaki Ocean Center
23	MIZUKA OSANAI	66	Female		Move The Walking YES	3	bus	kennsei hospital	Iwaki Ocean Center
11	SIZU OSANAI	82	Female		Mental Status YES	2	ambulance	kennsei hospital	Iwaki Ocean Center
6	MASAKI FUJITA	48	Male		Mental Status YES	2	ambulance	National Hirosaki Hospital	Iwaki Ocean Center
15	MISAKI ADACHI	38	Female		Move The Walking YES	3	bus		Iwaki Ocean Center
5	MASAFUMI HONNDA	64	Male		Mental Status YES	2	ambulance	kennsei hospital	Iwaki Ocean Center
18	HINANO KIKUCHI	83	Female		Move The Walking YES	3	bus		Iwaki Ocean Center
14	KOUKI TODA	86	Male		Respiratory Rate 9min or less,30min or more	1	ambulance	Hirosaki University Hospital	Iwaki Ocean Center

Figure 3 Chronologic list created by the information collection system.

headquarters. Seven Disaster Medical Assistance Teams comprising 8 medical doctors, 14 nurses, and 17 logistics staff participated. Also participating were 74 simulated patients, and 55 students.

We assessed the following 3 points: the impression of the participants who used the pens to write on the triage tags, the difference between the handwritten data and the digitized data, and the accuracy of the digitized data divided into three categories: check box, numeric characters, and letter characters.

Statistical analysis

Categorical variables are presented as numbers and percentages (%). For comparisons of the accuracy of the digitized data for each category, we used Fisher's exact test for categorical variables. A two-sided P value of < 0.05 was considered statistically significant, and all analyses were performed using JMP software (version 13; SAS Institute Inc., Cary, NC, USA).

Results

Tabletop study

We used 14 triage tag sheets to evaluate the written test data transmitted by Bluetooth to the PC and displayed on the monitor screen. All written data was displayed accurately, and transmission speed took only a few seconds. To evaluate whether a user could write well with the digital pen and whether it was as good as a conventional pen, we wrote on tags placed on a wet seat and found that all data was read accurately. The accuracy of the judgment of triage category based on the numeric values used on the START evaluation sheet was 100%.

Field study

We could collect data from 39 simulated patients. The impression of the users was that it was very easy to read and write on the triage tag, that it was convenient to use, and no

Table 1 Validity of Written Character Recognition

	Validity (%)	Number of correct answers (correct number/total number)
Check box	100	203/203
Numeric characters	68.2	135/195
Chinese characters	44.0	59/135

thought was given to writing pressure when using the digital pen. The simulated patients' information entered on the handwritten triage tag was quickly and accurately digitized and automatically transmitted as digitized data to a PC placed 10m from the triage area. There were no communication errors or data transfer problems. In terms of the display of the patients' transmitted data, it was organized chronologically, and the categorized lists were displayed rapidly and accurately. However, one problem was that quite a lot of detail was displayed on the list, and the data could not be read very easily. Assessment of the accuracy of the digitized data for each category showed that the check box data was completely accurate, whereas the errors in the numeric and letter characters were almost exclusively confined to content written in Chinese (Kanji) characters. The accuracy of the numeric characters was significantly higher than that of the letter ($P < 0.001$) and Chinese characters ($P < 0.001$), and the accuracy of the letter characters was significantly higher than that of the Chinese characters ($P < 0.001$).

Discussion

Our triage tag is a novel idea that uses a digital pen for data entry. This system could easily convert analog information into digital data. Digital data is easy to process for the creation of figures and tables, and these data can be transferred to remote locations. We also developed a new system that lists the collected data in a table format. The accuracy of recognition of the check boxes and numeric characters on the triage tag was high, but it was low for Chinese characters, so it will be necessary to enter data for the patient's name in Katakana (one of the Japanese syllabaries whose characters are easily recognized) in the future.

Distinctive to our system is the conversion of the patient's information to digitized data, thereby reducing the labor of writing by hand and facilitating further use of the data. Another merit of our system is that patient information could be quickly obtained everywhere, not only at the disaster control headquarters but also at other sections, such as triage posts, fire departments, and transport destination facilities and hospitals.

Bluetooth is a convenient service that functions to connect electrical devices such as PCs, tablets, mobile phones, and smartphones in near proximity to one another and is not affected by LANs or Wi-Fi service, which are often shut down in natural disasters. However, its utility is limited because Bluetooth's connection distance is only several dozens of meters. Although Internet service can connect areas over long distances through various devices, it is sometimes affected by natural disasters because of disruptions of the communication infrastructure. Its associated devices are crucial to the collection of information, and they cannot function if the Internet service is shut down.

Triage is one of the important operations in disaster medicine because of the decisions made on treatment strategy and prioritization. Most triage is performed on-site at the disaster-affected area. There is much confusion in the

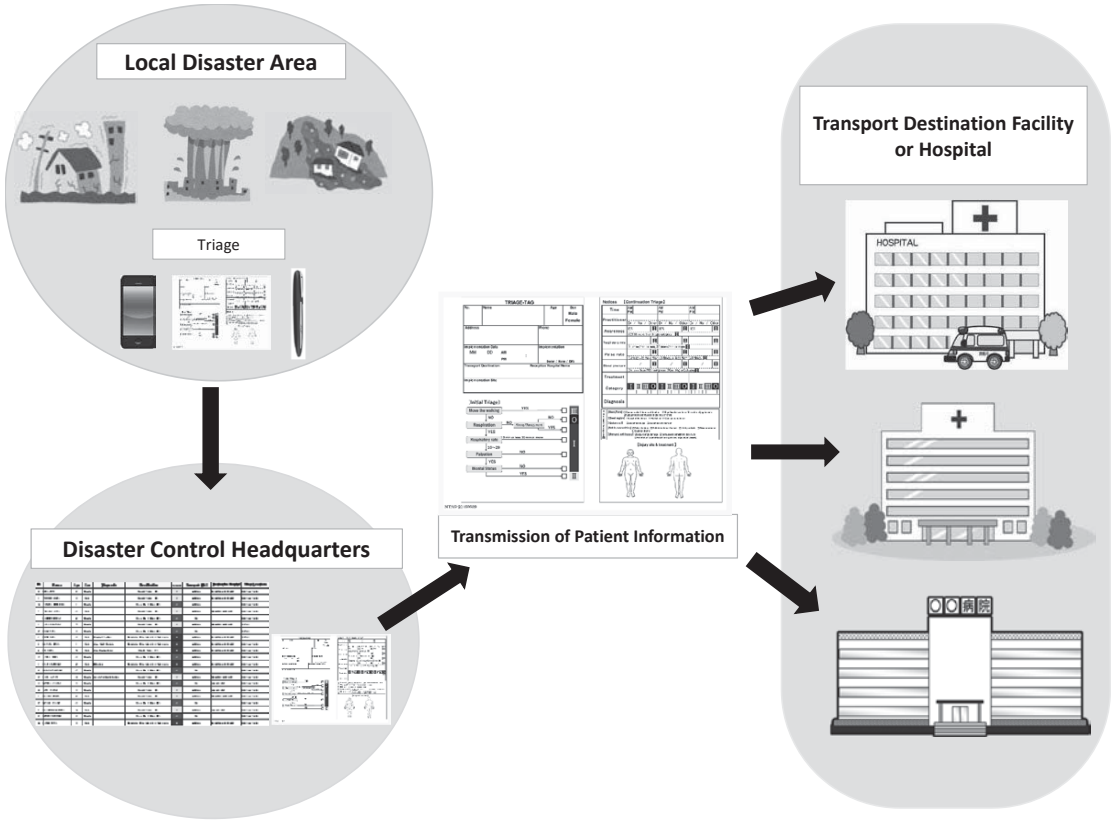

Figure 4 The scheme of our new system.

disaster-affected area because of information overload and the lack of medical equipment and human resources[14]. Therefore, the accurate tracking of patients and their data is important for medical treatment at mass casualty incidents. For example, during the Hurricane Katrina disaster, more than 12,500 adults and 5000 children were initially registered as missing[15]. One place where victims and/or critical medical information is 'lost' is in the transition from field care sites to hospital. Typhoons, hurricanes, tsunami, and floods are disasters in which the loss of this medical information can easily occur[16,17]. Problems with the loss of patient clinical data and/or lost linkages between patients and their clinical data occur even in field training.

Many information and communication technology devices are used at disasters worldwide[18-20]. The StatBand EMS triage tag was reported in the United States. This system scanned the triage tag information by bar code and input the patients' information using a wireless personal digital assistant. This information was then transferred to a central database system via the Internet. Another method introduced was electronic medical records[21]. Current disaster medical response involves paper tracking systems and radio communication for mass-casualty incidents. The WIISARD Research Group developed a handheld, linked, wireless electronic medical records system utilizing current technology platforms. Smart phones connected to radiofrequency identification readers may also be utilized to efficiently track casualties resulting from an incident. The report suggested that field testing in a number of exercises yielded excellent results, and future iterations will incorporate robust security measures.

Although new devices using information and

communication technology are being developed, most triage staff around the world use the paper tag because handwriting is easy to assess under confused and busy conditions, and electrical devices require much equipment for their use. Our triage tag has two merits: one is that the data is originally written by hand, and the other is that the analog data can be converted to digital data. During the confusion of a disaster, our new system might be a useful device that can accurately transmit patient information to various different areas.

This new triage system has some problems and limitations. First, recognition of numeric and letter characters was poor. Especially, Chinese characters are complicated and could not always be correctly interpreted by the character recognition system. Therefore, to reduce character recognition errors in the future, we will change our method of using check boxes on the triage tag and use Katakana, which uses Japanese characters not erroneously recognized, for written data entry. Second, our system requires the necessary use of a digital pen, a specific triage tag, and communication equipment such as a smartphone. Therefore, it will be necessary to distribute the new triage tag throughout our local area. Cost may be a problem if we use this system in the local area. However, we think it will be relatively easy to introduce the system because the manufacturing costs of our triage tag are the same as those for a conventional triage tag. Third, because we have not used this new system in a real disaster, we could not assess unknown problems that might occur during the confused situation of a real disaster. We must plan additional field studies, and we need to resolve the current problems with our system.

Conclusions

This new triage system using digitized information entered via a digital pen has some problems with the recognition of numeric and letter characters. However, this system almost exactly digitized the data and may be a useful device during disasters in the future.

Disclosures

Approval of the Research Protocol: N/A
Informed Consent (if applicable): N/A
Registry and the Registration No. of the Study/Trial: N/A
Animal Studies (if applicable): N/A
Conflict of Interest: Authors declare no Conflict of Interests for this article.

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