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The Study on Medication Vial Interface Design for Pumping Performance

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Abstract

Needlestick incidents are a frequent type of vocational injuries of nursing personnel worldwide. Medication vials are often used in injection, and during the fine needle aspiration (FNA), medical personnel may be accidentally punctured by the needle. The present study observed 98 professional medical personnel (with an average of five years of medical experience) performing a FNA from medication vials with four types of interfaces (MV1, MV2, MV3, and MV4), while the researchers measured the subjects' (1) FNA performance time, (2) FNA distance and (3) FNA subjective ratings. The results are as follows. First, in terms of the FNA performance time, the subjects did not show significantly differences in the FNA performance time among the four interfaces. In the case of FNA distance, the distance of MV2 was significantly better than of the other three interfaces. As for FNA subjective ratings, subjects showed the highest satisfaction with MV4. The experimental results revealed that for the interface design of medication vials, the use of a cross front sight and a yellow-blue contrast color-ring would significantly enhance the FNA distance and subjective ratings.

Keywords

Cross Front Sight, Contract Color-Ring, Medication Vials, Interface Design, Fine Needle Aspiration

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1. Introduction

In recent years, needlestick injuries have caused many medical personnel infected with hepatitis or AIDS, and some of them even died because of the infection [1]. As a result, needlestick injuries, a type of vocational injury, has caught great attention, and procedure related to preventing needlestick incidents has become a hot topic of discussion [2]. Needlestick injuries are one of the most frequently encountered injury by medical personnel, and studies have shown that 64.7% of nursing personnel had needlestick injuries by syringe needles, suture needles, and scalpels [3].

Among various types of medical procedure, recapping used syringes is very likely to cause needlestick injuries (about 16.5%) [4]. After giving one-handed recapping and no-recapping preventive education, significantly fewer puncture injuries happened. Aside from giving education and training, studies have shown that safety design can also effectively improve needlestick injuries [5-6].

Similar to nursing personnel, interns also belong to the high risk group of needlestick injuries because of their lack of experience [7]. Relevant studies have shown that due to the lack of experience, the needle stick injury rate of interns can be as high as 33%, and moreover, 97% of the injuries happened to the hands [8]. As for the just graduated nursing personnel, they in average require three to four months to get used to pressure from their new role [9].

Color is not only an important factor in medication vial interface design but also a factor frequently manipulated for better work efficiency. Studies have shown that when

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proofreading was performed in an office in white, more proofreading errors were made than proofreading done in either a red or blue office [10]. There are also studies demonstrating that color can increase the physical strength of an individual [11]. It was found in male college students that when they received a red stimulus, bigger grip strength was generated than when they received a green stimulus [12]. Another study demonstrated that in competitive sports, a team wearing red would be more likely to win [13]. Lastly, color has been applied frequently on product design. For example, there are studies showing that even though Alzheimer patients are usually less capable of differentiating between colors and are more likely to be underweight, the use of tableware of different colors for serving meals to patients with severe Alzheimer was found to improve their appetite and increase their body weight gain [14].

Another interface design factor explored in the present study was front sight. Relating studies have already applied front sight for precision improvement in product design [15] to resolve issues relate to the visual angle of tanks [16] or to increase the accuracy in shooting training [17].

Many needlestick injury studies consistently showed that nursing personnel view needlestick injuries as the major potential risk in the work environment and the injuries have created a certain level of mental stress affecting nursing personnel; nursing personnel fear of not only getting punctured but also getting infected by such injury, and the latter, according to nursing personnel, is more worrisome. Many safety devices have been designed and developed to correct the situation, but few studies explored the area about fine needle aspiration (FNA), i.e., drawing solution from medical vials. Some studies explored glass vials and proposed a concept called "blue dot" to remind nursing personnel to stay away from hazards [18]. In the present study, the focus was on the interface design of medication vials, and two designs, cross front sight and contract color-ring, were compared to determine which one is better in enhancing the FNA performance time and distance of nursing personnel while reducing their fear when performing the FNA.

2. Method

2.1. Subjects

The study randomly picked the subjects, i.e., medical personnel in Taiwan. Next, the researchers explained the experiment to the subjects and obtained their consents before distributing the structural questionnaires and carrying out the experiment. The research subjects had to meet the following criteria: (1) They work in the medical domain; (2) they need to have their handedness determined and use the dominant hand in the experiment.

To be objective, a total of 98 professional medical personnel with an average of more than five years of experience in the medical field were randomly sampled. Among them, 60.2% were nurses, 20.4% were research personnel, 13.3% were medical doctors (including doctor's assistant), and 6.1% were technicians or others. In terms of their gender, 75.5% were female, and 24.5% were male. The overall average of their age was 28.6 years old. All subjects used their dominant hand to carry out tasks in the experiment.

2.2. Instruments and Materials

Instruments and materials used in the study are as follows: (1) medication vials (8mm diameter) with a black-white contrast color-ring, coded as MV1, (2) medication vials (8mm diameter) with a cross front sight, coded as MV2, (3) medication vials (8mm diameter) with a red-green contrast color-ring, coded as MV3, (4) medication vials (8mm diameter) with a yellow-blue contrast color-ring, coded as MV4, (5) regular Terumo 3cc syringes, (6) individual profiles of the subjects, (7) a stopwatch with 1/100 second accuracy, and (8) a digital camera. The interface designs of MV1 to MV4 are shown in Figure 1.

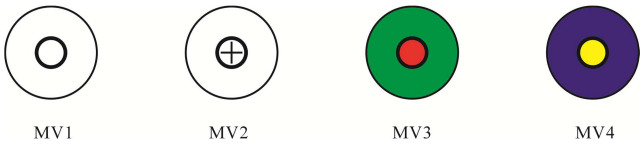

Figure 1. Interface Design of MV1-MV4.

2.3. Tasks

The medication vials (MV) used in the study were a commonly used type. With all four interface types (all with a diameter of 8mm), the subjects were asked to perform the FNA.

The FNA experiment comprised Tasks 1 to 4, and they were used to collect the following data of MV1 to MV4: (1) subjects' FNA performance time, (2) subjects' FNA distance, and (3) subjects' FNA subjective ratings.

2.4. Measurements and Experiment Procedure

The main objective of the study is to explore if the subjects' FNA use behavior varies depending on the interface design. With each interface, the researchers measured the subjects' FNA performance time, FNA distance, and FNA subjective ratings, and each criterion is described in more details below.

(1) Performance time: It is about the time spent by the subjects to complete a specific action. Theoretically, the less time spent by the subjects indicates that the specific interface has made the injection easier for the subjects.

(2) Distance: Subjects' FNA distance was rated based on the distribution of the needle insertion points.

(3) Subjective ratings: A psychological scale ranged between 1 (lowest satisfaction) to 5 (highest satisfaction) was used for assessing the level of fear of the subjects.

The researchers first explained to the subjects about the experiment actions and procedure and then asked the subjects to practice the experiment actions and procedure for 3 to 5 minutes. Before the experiment was officially started, subjects were allowed to arrange the syringe and the medication vial the way that is convenient for them. When the experiment began, the subjects were asked to take the syringe and to draw 1cc of water from medication vials MV1 to MV4 respectively, and when the FNA action was completed, they needed to return the syringe and the medication vial to the initially place. The researchers recorded the time used by the subjects to complete the action. To eliminate the so-called learning effect, the order of Tasks 1 to 4 was randomly assigned by the researchers. After completing the FNA experiment with the medication vials, the researchers asked the subjects to fill out the FNA subjective ratings questionnaire. The experimental procedure of Tasks 1 to 4 is as follows. In Step 1, the subjects were asked to remove the syringe cap. In Step 2, the subjects were asked to draw water from the medication vials, and the order of MV1 to MV4 was random. In Step 3, the subjects were asked to recap the syringe. In Step 4, the subjects were asked to put the syringe and the medication vials back to the initial place. Lastly, in Step 5, the researchers recorded the results. More details of Tasks 1 to 4 are presented below.

(1) Task 1: The subjects used a Terumo 3cc syringe to draw 1cc of water from the medication vial with a black-white contrast color-ring. The researchers recorded the FNA performance time (in seconds) and distance (mm) of the subjects as well as their subjective ratings.

(2) Task 2: The subjects used a Terumo 3cc syringe to draw 1cc of water from the medication vial with a cross front sight. The researchers recorded the FNA performance time (in seconds) and distance (mm) of the subjects as well as their subjective ratings.

(3) Task 3: The subjects used a Terumo 3cc syringe to draw 1cc of water from the medication vial with a red-green contrast color-ring. The researchers recorded the FNA performance time (in seconds) and distance (mm) of the subjects as well as their subjective ratings.

(4) Task 4: The subjects used a Terumo 3cc syringe to draw 1cc of water from the medication vial with a yellow-blue contrast color-ring. The researchers recorded the FNA performance time (in seconds) and distance (mm) of the subjects as well as their subjective ratings.

3. Results

Performance time

Data on FNA performance time were examined by the ANOVA. The independent variable was the FNA interface, including MV1, MV2, MV3 and MV4, while the dependent variable was the time spent for inserting the needle into the vial. The statistical result gave F=0.377 with P=0.77, suggesting a lack of significant difference. Therefore, interface type did not affect the FNA performance time.

3.1. Distance

Data on FNA distance were examined by the ANOVA. The independent variable was the FNA interface, including MV1, MV2, MV3 and MV4, while the dependent variable was the distance between the point where the needle was inserted into the vial and the center of the circle. The statistical result gave F=10.920 with P=0.000, suggesting that FNA distance differed significantly depending on the type of interface. The Least Significant Difference (LSD) was used for further analysis, and the result showed that for FNA distance, MV2 was significant better than the other three interfaces.

3.2. Subjective Ratings

Data on FNA subjective ratings were examined by the ANOVA. The independent variable was the FNA interface, including MV1, MV2, MV3 and MV4, while the dependent variable was the level of subjective ratings (rated using A Liker Scale ranged from 5 (highest satisfaction) to 1 (lowest satisfaction)). The statistical result gave F=4.087 with P=0.000, suggesting that FNA subjective ratings differed significantly depending on the type of interface. The Least Significant Difference (LSD) was used for further analysis, and the result showed that the subjective ratings of MV3 were significantly lower than of the other three interfaces.

Statistical data of the effect of interface type (MV1, MV2, MV3, and MV4) on the study subjects' FNA performance time, distance, and subjective ratings are presented in Table 1.

Table 1. FNA Performance Time, FNA Distance, and FNA Subjective Ratings of MV1 to MV4.

No.	Items	MV1		MV2		MV3		MV4		F value	P value
		Mean	SD.	Mean	SD.	Mean	SD.	Mean	SD.		
1	Performance time	15.92	1.50	15.88	1.29	15.72	1.35	15.86	1.25	0.377	0.770
2	Distance	1.80	0.94	1.19	0.73	1.77	0.85	1.64	0.80	10.920	0.000
3	Subjective ratings	3.59	1.12	3.81	1.06	2.94	1.04	3.73	0.95	14.087	0.000

4. Discussion

The study used the design of experiment to find out a better medication vial interface design that could reduce the rate of needlestick injuries in nursing personnel while allowing the FNA to be done more quickly and accurately.

For FNA subjective ratings, the obtained experimental results are presented below. Interface type was found to have a significant effect on FNA subjective ratings. More specifically, the interface design of MV3 had a significantly lower satisfaction score. MV3 was the code for the medication vial with a red-green contrast color-ring, and according to the subjective rating results, subjects were significant dissatisfied with this color pair. On the other hand, the satisfaction of the MV4 medication vial (with a yellow-blue contrast color-ring) was significantly better than of the MV1 medication vial (general medication vial interface). The reason why subjects in general accepted the medication vial with a yellow-blue contrast color-ring but not the one with a red-green contrast color-ring shall be discussed in the next paper.

5. Conclusion

For FNA performance time, the obtained experimental results are presented below. No association was found between the type of interface and FNA performance time. It is possible that because the subjects were mostly experienced medical personnel, their accumulated aspiration experience might have blocked the effect of interface type on their FNA performance time.

For FNA distance, the obtained experimental results are presented below. Interface type was found to have a significant effect on FNA distance, and the FNA distance of MV2 was significant better than of the other types of interface. MV2 was the code for the cross front sight, and aside from color cues, this is the only one from the four types of interface that provided a clear identification. This finding suggested that even though color is not very useful in improving the FNA distance, including a cross front sight in the medication vial interface, nevertheless, could significantly and effectively enhance FNA distance, thereby reducing the needlestick injury rate in nursing personnel.

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References

[1] Leliopoulou C, Waterman H, Chakrabarty S. (1999) Nurses failure to appreciate the risks of infection due to needle stick accidents: a hospital based survey. The Journal of Hospital Infection 42 (1): 53-59.

[2] Zafar AB, Butler RC, Podgorny JM, Mennonna PA, Gaydos LA, Sandiford JA (1997) Effect of a comprehensive program to reduce needlestick injuries. Infection Control & Hospital Epidemiology 18 (10): 712-715.

[3] Rattner SL, Norman SA, Berlin JA (1994) Percutaneous injuries on the "front line": a survey of housestaff and nurses. American Journal of Preventive Medicine 10 (6): 372-377.

[4] Farsi D, Zare MA, Hassani SA, Abbasi S, Emaminaini A, Hafezimoghadam P, Rezai M (2012) Prevalence of occupational exposure to blood and body secretions and its related effective factors among health care workers of three Emergency Departments in Tehran. Journal of Research in Medical Sciences 17 (7): 656-661.

[5] Sellick JJ, Hazamy PA, Mylotte JM (1991) Influence of an educational program and mechanical opening needle disposal boxes on occupational needlestick injuries. Infection Control & Hospital Epidemiology 12 (12): 725-731.

[6] Schaffer S (1997) Preventing nursing student exposure incidents: the role of personal protective equipment and safety engineered devices. Journal of Nursing Education 36 (9): 416-420.

[7] Wang FD, Chen YY, Liu CY (2000) Analysis of sharp-edged medical-object injuries at a medical center in Taiwan. Infection Control & Hospital Epidemiology 21 (10): 656-658.

[8] Shen C, Jagger J, Pearson RD (1999) Risk of needle stick and sharp object injuries among medical students. American Journal of Infection Control 27 (5): 435-437.

[9] Horsburgh M (1989) Graduate nurses' adjustment to initial employment: natural field work. Journal of Advanced Nursing 14 (8): 610-617.

[10] Kwallek N, Lewis CM, Lin-Hsiao JWD (1996) Woodson H. Effects of nine monochromatic office interior colors on clerical tasks and worker mood. Color Research and Application 21 (6): 448-458.

[11] Setchell JM (2001) Dominance, status signals and coloration in male mandrills (Mandrillus sphinx). Advances in Ethology 111: 25-50.

[12] O'Connell BJ, Harper RS, McAndrew FT (1985) Grip strength as a function of exposure to red or green visual stimulation. Percept Mot Skills 61 (3): 1157-1158.

[13] Hill RA, Barton RA (2005) Psychology: Red enhances human performance in contests. Nature 435: 293.

[14] Volicer L, Rheaume Y, Cyr D (1994) Treatment of depression in advanced Alzheimer's disease using sertraline. Journal of Geriatric Psychiatry and Neurology 7 (4): 227-229.

[15] Blasing F (2007) Integrated Design and Functional Solution for a Camera Front-End in the Windshield Sensor Cluster. SAE Technical Paper 2007-01-0393.

[16] Xu C, Jianing D, Zhang S, Wang W (2013) Infrared telephoto design used in joint transform correlator. Key Engineering Materials 552: 21-26.

[17] Zhao H, Zhang H (2014) Shooting training method optimization research based on fluid mechanics and fuzzy theory. BioTechnology: An Indian Journal 10 (5): 1079-1083.

[18] Ismail A, Ismail M (2007) Preventing glass injuries in the emergency department. Emergency Medicine Journal 24 (1): 69.