Case Report

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Development of a Safe Syringe Disposal System Moving towards Automated Syringe Data Collection

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Objectives: An automatic needle destroyer (ANDY) was developed to prevent needlestick injuries, and usability tests were conducted in several hospitals. The addition of extra features to the ANDY is in progress, such as data collection and automatic identification of used syringes. Thus, this report describes how the ANDY can be used to track the data of used syringes. **Methods:** The motor torque required for barrel separation differs according to syringe diameters. By monitoring the electric current which is consumed for the motor torque, the type of syringe can be identified. Twelve prototypes were produced, and five usability tests were conducted in hospitals. **Results:** After use, a syringe is inserted into the proposed device, and the needle portion is then cut and separated from the syringe body (barrel) and discarded. The needles are collected in a sharps container for hygienic disposal, and the barrel is dropped into a general medical waste container. **Conclusions:** The ANDY can be used to track the syringe used for each patient. The barcode can be read while the syringe rotates in the main body of the ANDY with a built-in omnidirectional scanner. Collection of information during syringe disposal can facilitate stock management. This system could also be extended to other types of consumable medical devices, although it would still be a challenge to differentiate each medical device.

Keywords: Medical Waste Disposal, Needlestick Injuries, Disposable Equipment, Equipment and Supplies, Equipment Design

I. Introduction

Outbreaks of hepatitis B and C in New York, Oklahoma, and Nebraska were reported between 2000 and 2002, during which it was found that transmission occurred indirectly from one patient to others after exposure to re-used syringes [1]. Similarly, in Seoul, Korea, hepatitis C virus transmission occurred within a large group of patients who were treated in various clinics from 2015 to 2017 [2]. According to the results of an epidemiological investigation, this particular outbreak was strongly associated with the re-use of syringes [2]. Due to safety concerns such as these, data tracking of medical devices from production to use has been proposed as a way to improve medical safety. For example, the International Medical Device Regulators Forum proposed guidelines for its ten member countries as part of the Unique

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Device Identification (UDI) system. The UDI system is designed to fully monitor the process of delivering medical devices to individual patients by issuing a unique device identifier [3]. Each medical device includes a UDI in human- and machine-readable form using letter codes and barcodes [3].

Syringes are hazardous both patients and the healthcare providers who directly handle them. Needlestick injuries (NIs) are stab wounds from needles that may result in exposure to blood or body fluids; they carry the considerable risk of blood-borne infections, such as HBV, HCV, and human immunodeficiency virus (HIV). According to a research conducted by the Occupational Safety and Health Research Institution in 2012, there were 8.98 NI cases per 100 beds and 4.29 NI cases per 100 medical personnel in Korea annually [4].

To prevent NI, a number of safety engineered devices (SEDs) have been designed. SEDs are medical devices designed with the intention to prevent hazards and accidents [5]. In the case of safety engineered syringes, needles are covered or bent immediately after being used. However, the introduction of SEDs is not sufficient to reduce the number of NIs. This is because SEDs is need to be manually handled to cover the sharps after use. If healthcare providers are unfamiliar with using SEDs, accidents can still occur. According to a study conducted by Mitchell et al. [6] in 2017, SED-related injuries accounted for 35.3% of all incidents of exposure to blood and/or body fluids in the United States, and it showed an upward stream from 2009 to 2014. In this article, we propose a method to decrease the incidence of NI without changing the existing injection technique and a one-stop solution to automatically dispose of needles and syringe barrels.

II. Case Description

The automatic needle destroyer (ANDY) was developed to prevent NI, and usability tests were conducted in several hospitals. The addition of extra features to the ANDY is in progress, such as data collection and automatic identification of used syringes.

1. The Objective of Product Development

According to the Exposure Prevention Information Network (EPINet) surveillance system in the United States, around a quarter of NIs occur after using and while disposing of sharp objects (23.5%) [7]. The ANDY was developed with the goal to facilitate automatic separation and disposal of syringes without additional handling. In this way, the ANDY not only prevents NI but also collects information about the disposed syringes.

2. Methods

1) Product configuration

The ANDY is an automatic needle destroyer. After use, a syringe is inserted into the device, and the needle portion is then cut and separated from the syringe body (barrel) and discarded. The needles are collected in a sharps container for hygienic disposal, and the barrel is dropped into a general medical waste container. In Korea, because almost all sharps containers and general medical waste containers are attached

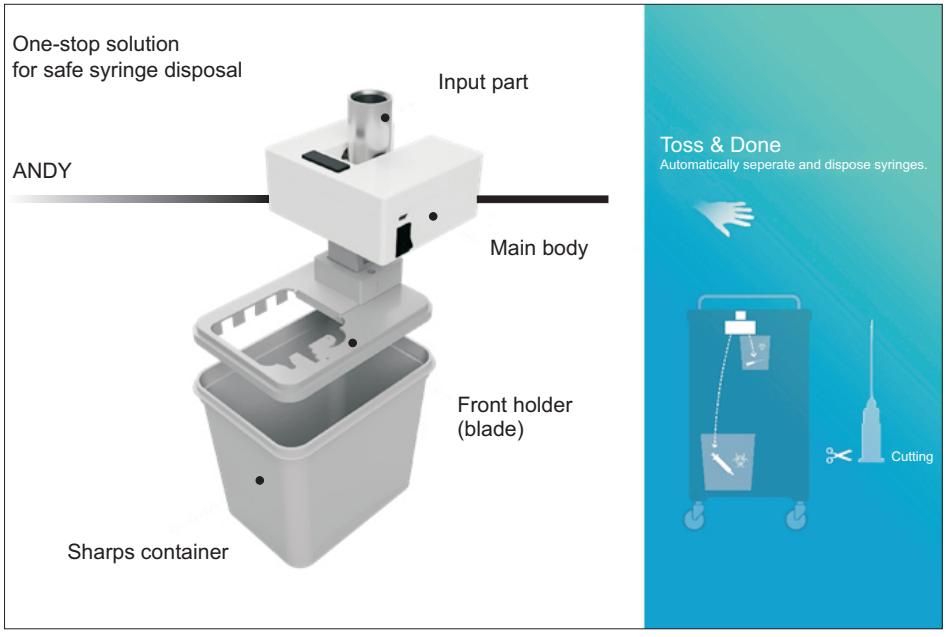

Figure 1. Product configuration and usage. ANDY: automatic needle destroyer.

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to the side of a medical cart, the proposed device is mounted above the sharps container (Figure 1). Since types of sharps containers vary according to hospital, a 3D-printed front holder is adjusted to accommodate these various sharps containers. The front holder including a blade is designed as a disposable product, and discarded in accordance with replacing the sharps container. This is because the front holder is easily contaminated by blood or body fluids.

2) Device optimization

Twelve prototypes were produced, and five usability tests were conducted in hospitals. Nurses' feedback was collected regarding the number of syringes that can be inserted at a time, the processing speed and method, and size of the product. Based on this feedback, the product was modified to both improve the user experience and suit the hospital environment. Furthermore, the other qualitative data were obtained through observing and analyzing behaviors of healthcare providers, such as, the convenience of module replacement and other potential problems related to usability and product installation.

3) Syringe usage data collection

(1) Motor monitoring

The diameter of syringe barrels varies based on the syringe volume from 1 to 50 mL. The motor torque required for barrel separation differs according to its diameters. Therefore, by monitoring the electric current which is consumed for the motor torque, the type of syringe can be identified. Data collection algorithm can be constructed by calibrating the collected data according to the type of syringe. However, due to potential variation in the angle of input, the classification algorithm should be optimized through machine learning.

(2) Scanning

Pre-filled syringes which are used for flushing normal saline and vaccines are specified with a bar code or a QR code. The barcode can be read while the syringe rotates in the main body of the ANDY with a built-in omnidirectional scanner. The application of this barcode scanning method while disposing waste can be expanded to collect information of other medical wastes throughout the whole hospital.

III. Discussion

Although the ANDY can be used to track the syringe used for each patient within the UDI system, it is often difficult to trace the individual use of syringes because the UDI label is placed on each box of syringes, not each syringe individually. For this reason, Unit of Use Device Identification, in which the indicator is assigned to a single package unit, has been proposed as an alternative. However, this requires healthcare providers to manually enter significant amounts of information. If the ANDY is used to collect data from medical devices automatically, time and labor costs can be reduced remarkably.

Collection of information during syringe disposal can facilitate stock management. In most cases, consumable medical devices are managed using empirical statistics; that is, consumable medical device use is typically measured by periodically noting changes in stock. However, this method does not indicate whether the medical equipment is used for patients or not. It is possible to monitor the real-time usage of syringes if the ANDY collects syringe information during disposal. This system could also be extended to other types of consumable medical devices. However, having the system differentiate between medical devices of different shapes and sizes remains a challenge.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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