Colorimetric Time Indicator for IV Notification

Nick Anderson John Cheadle Ali Johnson Ella Li

Client: Scott R. Springman, MD[1] **Advisor**: Wan-Ju Li, PhD[2]

[1]Department of Anesthesiology – University of Wisconsin Hospital

[2]Department of Biomedical Engineering – University of Wisconsin-Madison

Abstract

Intravenous (IV) therapy is frequently used to deliver medicine or other fluids directly into the vascular system. This technique breaks the skin barrier, creating a constantly open wound. To prevent infection, the catheter is moved to a different part of the body every 72 to 96 hours[1]. In order to ensure the catheter gets replaced, the date and time of catheter insertion is printed on a label and attached to the IV tubing. However, this is easily overlooked, creating the need for a more noticeable design.

The new notification design is an electric timer, which illuminates LEDs and activates an alarm at certain programmable time periods [with default at 72 and 96 hours] while the IV is inserted. The final prototype was constructed and programmed with an Arduino Duemilanove USB board and various circuit elements. It was then placed in an acroylonitrile-butadien-stryene (ABS) case with a Velcro strap to connect it to IV tubing.

Initial testing was completed, confirming the benefits of the LED design compared to the current method. Future work will consider minimizing size and power consumption, along with incorporating wireless technologies to integrate the device with monitoring systems and electronic medical records.

Background

IVs are used for…

- Infusing medications
- Transfusing blood or blood components
- Providing nutritional support

IV components (figure 1)

Figure 1: Peripheral IV lines consist of IV fluid, a drip set, connector tubing and a catheter.

Image courtesy of dvm360: http://marketplace.dvm360.com/community/UserFiles/abbott.jpg

Motivation

- Catheter creates a constantly open wound which increases the chances of infection
  - Rash, fever, swelling[2]
  - Systemic inflammatory response syndrome
    - Death rate of 40% and up to 80% for elderly[3]

Goal: To create a device that notifies medical personnel when an IV needs to be changed.

Design Criteria

Cost Effective
- Mass production cost under $5 per device
- Design and prototype budget under $100
- Reusable (no excess waste)

Functional
- Accurate time intervals based on light changes (at 0, 72, and 96 hours)
- Ergonomic
- Patient-proof power button
- Functions independent of environment

Materials & Safety
- No exposure to hazardous chemicals
- Contains no latex
- Can be wiped with disinfectant wipe after use to ensure sanitition

Final Design

Design Concept
- Electric time indicator
- LEDs indicate status of IV tubing to medical personnel

Time Indications
- Green: 0 – 72 hours (okay)
- Yellow: 72 – 96 hours (warning)
- Red: > 96 hours (danger)
- Time intervals are reprogrammable

Additional Features
- Reset button turns device on and off
- Speaker gives audio signal when IV tubing needs to be changed
- Strap allows for easy attachment to IV tubing

Figure 2: On the final prototype (CAD drawing on the left, photograph on the right), the LEDs, reset button, and speaker are all located on the face of the device. All these components are enclosed in a hard, plastic casing. The strap is attached to the back of the casing, opposite the other components.

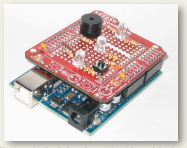

Figure 3: Arduino board with soldering board

Arduino Board (Figure 3)
- ATmega168 microcontroller
- Reprogrammable
- Powered via USB or other external power supply (7-12 input voltage)
- Easily connects to soldering board

Figure 4: Velcro strap with rubber strip on the back of the final prototype

Strap (Figure 4)
- Velcro strap integrated with rubber strip
- Rubber strip
  - Create friction
  - Prevent device from slipping

Figure 5: ABS casing

Casing (Figure 5)
- Acroylonitrile-butadien-stryene (ABS)
- Two-piece
- Five holes drilled into face
  - Three LEDs
  - Speaker
  - Reset button

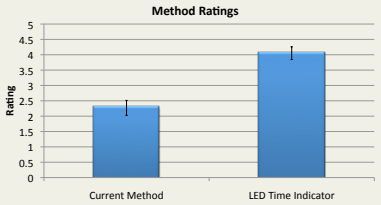

Figure 6: A survey was distributed to medical personnel with IV experience who rated certain aspects of each design on a scale from 1 to 5. The current solution results (n=13) gave a mean of 2.3, a standard deviation of 0.88 and a standard error of 0.24, while the LED Time Indicator (n=13) had a mean of 4.05, a standard deviation of 0.75 and a standard error of 0.21.

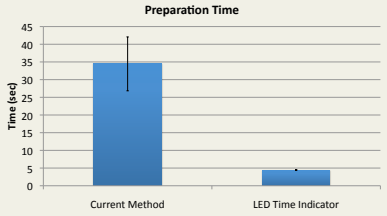

Figure 7: The average time of set up was acquired via a survey for the current solution and via testing for the LED Time Indicator. Results showed that the current solution (n=9) has a mean of 34.4 seconds, standard deviation of 22.83 seconds and a standard error of 7.612 seconds while, the LED Time Indicator (n=10) had a mean of 4.45 seconds, a standard deviation of 0.43 seconds and a standard error of 0.14 seconds.

Competition

Current Solution
(Figure 8)
- Date and time of insertion printed on a label
- Label attached to IV tubing

Figure 8: Current solution is a handwritten label that attaches to tubing

Image courtesy of MarketLab: http://www.marketlabinc.com/files/products/images/medium/m5786a.jpg

OnVu Sticker[4]
(Figure 9)
- Color-changing sticker
- Time and temperature dependent
- Activated by UV light
- Becomes progressively lighter

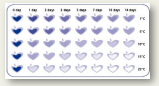

Figure 9: OnVu Sticker[4] changes color due to time and temperature

Image courtesy of OnVu http://www.onvu.com

Visually Changing Paper[5]
- Two-part paper-like product used for ID badges
- Adhesive front layer is sensitive to pressure
- Product is activated by placing the front layer to the back image layer
- Image is revealed after established time period (minutes to days)

Future Work

Design Optimization
- Reduce size
- Minimize power consumption
- Create a more user-friendly time display interface
- Design a streamlined, wireless system consisting of multiple indicators connected to a main computer

Mass Production Considerations
- Greatly reduced cost per device
- Fully battery-powered
- More manageable attachment to IV tubing

Further Testing
- Operation of device in clinical setting
  - Medical staff and patient satisfaction

Acknowledgements

•Scott Springman, MD
•Wan-Ju Li, PhD
•Andrew Gierke
•Amit Nimunkar
•Thomas Yen
•Walter Block

References

[1] Soifer NE, et al. "Prevention of peripheral venous catheter complications with an intravenous therapy team". Archives of Internal Medicine 1998; 158: 473-477
[2] O'Grady, N. et al. "Guidelines for the Prevention of Intravascular Catheter related Infections." 2002. Clinical Infectious Diseases 35(11): 1281-1307.
[3] Stoppler, Melissa. "Sepsis (Blood infection)." Web MD. 2008. Viewed on Oct 8, 2009 http://www.webmd.com/a-to-z-guides/sepsis-blood-infection
[4] Haas, D. "Times-up! The color-changing self-expiring badge." *Chemical innovation* 31.2 (2001): 42-51.
[5] BASF, "OnVu", 2009. Web. 22 Nov. 2009. <http://www.onvu.com/_en/how.asp>.