ENGR 103 - Spring 2013
Freshman Engineering Design Lab

The M.I.V.
Project Design Proposal

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Abstract:

The motivation for this engineering design project came from the millions of patients that receive care from hospitals and hospices that need intravenous (I.V.) therapy. These patients are limited to only being able to move where the metal I.V. rack will allow them to go, so the project goal is to create a mobile intravenous (M.I.V.) system so that the patients can receive the treatment that they need at any location. The invention of this device would aid the comfort and mobility of tens of thousands of people on a day to day basis. The technical challenges of the project include finding the best materials to make the prototype with that keeps the cost relatively low and using machines to physically make the M.I.V. model. The final deliverables include a computer aided design of the M.I.V., a functional prototype, and a blog detailing the design process at www.du2013-grp110-12.blogspot.com.

1. Introduction

Problem Statement and Overview

The motivation of this project is to aid the millions of patients who visit any of the 5,815 hospitals in the U.S. that need to use an I.V. bag during their treatments. The main problem with the standard I.V. bag on a metal rack is the discomfort of using the apparatus. It is a very large device to be moved about, and it immediately signals to others that the person using it is different in some way. The project aims to create a device that would give these poor people more freedom and a sense of normalcy to their lives. The objective of the redesigned I.V. apparatus includes a more functional device that is lightweight, more mobile, and discrete.

Some challenges stand in the way of the objectives, however. A medical license is needed to purchase an I.V. Bag. To circumvent this, the project applies a dimensionally similar 500ml parenteral feeding bag as a simulation for the I.V. bag. Second, one of the parts necessary to the device turned out to be too large and too costly to be printed out on one of the Drexel University 3-dimensional printers. This obstacle was passed by using waterproofed, sanded lumber to create a workable model of that part. Finally, because the project was not funded, cost was a very large constraint. It was decided to try to keep the overall cost below one hundred twenty dollars. This limit forced creativity and ingenuity on the part of the group.

The vision behind the new device, suitably called the M.I.V. or Mobile Intravenous, was essentially a compression chamber, into which the I.V. bag would be place that would be attached to a small harness that could be comfortably worn. The pressure would make up for the lack of gravitational force on the I.V. bag and the harness would give it a little more discreteness.

The learning objectives for the betterment of the M.I.V. include in depth knowledge of the rate at which the I.V. drip occurs to better replicate it, appropriate knowledge to design the CAD drawing, and the ability to use certain machines in the Hess building to finally create the product. The M.I.V. could benefit a vast array of people; the elderly and ill under hospice care require a less bulky I.V. apparatus, young patients in hospitals that need lightweight mobility and discretion, people unable to digest food orally, and anyone looking for more freedom and mobility on intravenous treatment. The desired outcomes are to benefit and improve the lives of people who have already gone through enough by providing a mobile intravenous system.

Existing Solutions

The current, most commonly used method to medicate patients through intravenous therapy is to hang the I.V. bag from a large, metal I.V. stand that contains hooks at the top, a long pole, and a base with wheels. The idea behind this assembly is that the bags hang well above the patient so that the medication will flow from the bag down the tube and ultimately into the patient just by the force of gravity [1]. This solution is satisfactory for patients who are stationary all day and don't change position, but it is not an ideal design for the majority of patients. The whole metal assembly is very cumbersome and has poor maneuverability, making it unstable when patients move around. Also, since the flow rate of the medication is directly affected by gravity, whenever the patient changes position the pole must be adjusted so that the flow rate stays the same. Overall, this current solution is functional, but it is not an ideal device that allows mobility.

Figure 1. Standard IV Stand with Double Hook [2]

Project Objectives

At the conclusion of this project, the three main deliverables are: the prototype, computer aided drawing, and a blog. A Creo Parametric depiction of the compression compartment was used as a guide for constructing the prototype. The Mobile Intravenous combines the harness section and the compression compartment. The harness section was designed by applied research done on pre-existing harnesses holding fluids such as Camelbaks and used by runners and the military. Prototype testing was conducted at Queens Lane Medical College and given to a medical professional to critique. Their feedback serves as evaluation for the M.I.V. Prototype. The completion of this project includes a CAD drawing, tangible prototype, and quantitative, qualitative, and visual data of the design process detailed in a blog.

Project Constraints

For this project several constraints limited the design possibilities. The first and main constraint was money. The budget was set at a one hundred and twenty dollar maximum, so innovative ideas were needed to actually complete the prototype. Also, the limited time window in which the project was set did not allow for many modifications of the design; once the creation of the prototype was in progress there was no time to start over. The materials with which the M.I.V. was built were a constraint as well. Initially it was desired to create a three-dimensional, plastic compression chamber, but this would have far exceeded the set budget, so it was decided to create a wooden compression chamber prototype. Finally, actually obtaining an I.V. bag was a constraint. A medical license is needed to purchase these bags, so the prototype was based on a parenteral feeding bag.

2. Technical Activities

Major technical tasks of the project include literature study, material collection, prototype design, and testing. The following sections detail how these challenges were addressed during the project.

2.1 Literature Study

Design aspects incorporated from research include: ergonomics of user comfort to the 95th percentile, existence of similar designs, material properties such as weight, water absorbency, corrosion, appeal, and cost. The venous pressure was calculated based on researched formulas so that the compression can overcome fluid backflow [3]. Comparable data of the information above helps identify the most compatible components of the alternative designs.

2.2 Material Collection

The compression includes a wooden compartment surrounding the I.V. bag, a metal slate, and springs. External materials include a fabric pouch and polyester straps from a backpack.

2.3 Prototype Design

The compression compartment was the most intricate portion of the design requiring a CAD drawing as a visual guide for machining. A compression slate was cut from metal sheets and adhered to several compression springs. The compartment for this prototype was constructed from pine due to the high cost of 3D printing plastic as our first option [4]. A parenteral feed bag of similar dimensions (500 ml) was purchased as a substitute for the I.V. bag [5].

2.4 Testing

Testing is another challenging technical activity to conduct after a prototype has been constructed. Evaluations of the prototype need to be tested to ensure that the prototype can perform effectively. Feedback was collected from an interview with emergency medicine expert Dr. Neal Handly. Evaluations expose any design weaknesses to adjust the prototype accordingly and improve the future designs.

3. Project Timeline

The project timeline is a Gantt table of all the project activities and estimated time necessary to complete each activity.

	Week									
Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Alternative Design Brainstorm & Proposal	**x**									
Literature Study on existing solutions	**x**	**x**	**x**							
Material Collection and calculations			**x**	**x**	**x**	**x**				
Prototype construction at Hess Labs				**x**	**x**	**x**	**x**	**x**		
Interview with Dr. Neal Handly							**x**	**x**	**x**	
Final report and Presentation								**x**	**x**	**x**

Table 2: Mobile Intravenous project timeline

4. Budget

The budget is a cost guide to limit over-spending during material purchasing.

Category	**Projected Cost**	**Actual Cost**
500 ml I.V. bag	$40.00	$14.00
Backpack	$60.00	$20.00
Compartment materials	$20.00	$63.00
TOTAL	**$120.00**	**$97.00**

Table 3: Mobile intravenous prototype budget

5. Results

Design Alternatives

Criteria and constraints of the mobile intravenous specifically define the project design based on goals and limitations. During the process of creating the M.I.V. prototype, several alternative designs were compared for two main components: the compression chamber and the harness straps (Table 1). For the compression chamber, the ideas of using rubber bands, a zip-able compressive compartment, and a spring slate compartment were debated. The spring slate compartment was finally chosen. Alternative straps of using one horizontal strap, two vertical straps, and straps with the metal I.V. bar attached to them were debated. However, it was decided that the metal I.V. bar would destroy the discrete nature of the device, and the two vertical straps were ultimately decided upon based on the results seen in the table below.

	Criteria:	user mobility	user comfort	stablility (in motion)	easily changed	discretion	weight	**Total**
Alternative Strap Designs:								
Raised metallic bar I.V. strap		1	2	1	5	2	2	13
Single cross body frontal I.V. strap		3	4	4	3	4	5	23
Two Vertical frontal I.V. straps		4	5	5	4	4	4	26
	Criteria:	compress	thicknes	discretion	easily changed	**Total**		
Alternative Compresion Designs:								
Rubber band compressed I.V. compartment		4	5	4	1	14		
Two zipper compressed I.V.compartment		2	4	4	3	13		
Spring slate compressed I.V. compartment		5	3	3	5	16		

Table 1. Mobile Intravenous Design Matrix

Final Design and Specifications

The final M.I.V. prototype is a one foot by one foot by five inches backpack with a compartment for the compression chamber. The harness/backpack part of the M.I.V. was designed to be very small on purpose, so that a three year old child could easily and comfortably wear it. There are also adjustable straps so the device can fit on virtually anyone. The compression chamber itself is 5.25 by 7.5 by 3.5 inches so it could successfully fit in the designated compartment on the harness/backpack. The compression chamber has a metal wall attached to springs. This allows the metal wall to be pushed back, and the I.V. bag to be placed inside the chamber. The wall is released and pressure is exerted on the bag, pushing the fluids through the tube. The tube itself runs through a small hole in the bottom of the compartment on the backpack/harness. The tube can then run down the underside of the wearers discretely until it reaches the wrist area. The M.I.V in total weighs only 2.73lbs without the filled I.V. bag. This accommodates a very young child, which was the goal. The shoulder straps are also padded and comfortable, and allow for extended wear time. The figure below displays the finished M.I.V. prototype.

Fail-Safe and Unintended Consequences

The M.IV. is equipped with a fail-safe, just in case the compression chamber should malfunction and unintended amounts of fluid be distributed. The standard IV bag itself has a nozzle which can cut off the flow of liquids from the bag. So, if an unforeseen circumstance arose, one merely has to slide the harness off of their shoulders and rotate the nozzle to the closed position. However, this may not be satisfactory for extremely weak patients who are unable to even take the backpack off, so a new idea was devised for future application. It was thought that instead of a solid compression chamber, in the future, a pressurized, inflatable compartment implemented into the harness could be used. The IV bag would slide into this compartment. Then one would have to pump up the inflatable sides of the compartment until the pressure gauge read the appropriate amount of pressure. With this set up a fail-safe button would be implemented. In case of emergencies, the user would press this button, which would open one or two hinged doors, effectively releasing the pressure and causing the loss of fluid flow. This would then give the user more time to be helped out of the harness.

Some unintended consequences of the M.I.V could result from the excess freedom given by the device and its discrete nature. For example, a child wearing this could possibly run away or get lost in a hospital because he is no longer attached to the intravenous rack. Also, the device could potentially be used to smuggle objects into and out of hospitals. Employees would have to check the M.I.V.'s very thoroughly before entry or exit from hospitals. Also, there is the possibility that the IV bags could pop from the pressure of the compression chamber or rigorous external activities by the patient. However, if the patient is that rugged with the device, he or she is most likely only on saline solution, but the popping of the bag is still an undesired event. Finally, the M.I.V. could possibly be used for illegal drug use. This would be a terrible occurrence, and to prevent it one would most likely need a medical license or a doctor's approval to purchase one.

6. Conclusion

The final deliverables of the mobile intravenous project include the computer aided designs of the M.I.V., a prototype, and a blog detailing the design process. The functional prototype derived from the drawings fulfill the project objective to redesign the I.V. rack includes a more functional device that is lightweight, more mobile, and discrete. Limitations of the final design include time, cost, and availability of resources. Due to the ten week duration of the engineering 103 lab, less time was contributed to each component of the design process. If more time were allocated, then there would be more research collected to generate better alternative designs to incorporate into the project. Another major limiting factor of the project was cost. To stay within the budget, cheaper materials were selected for the prototype, rendering it less effective and heavier than ideal. Pine lumber was used to replace the intended plastic compartment for the mobile intravenous. This cost limiting factor also is also related to the resource limiting factor. Since intravenous bags require a medical license to purchase, the engineering team was not able to acquire one legally and opted to buy a feeding bag of similar dimensions. Despite these limitations, the initial objectives of the project were achieved.

7. References

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