Patient Transfer Device

Mid-Semester Report
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Client: Dr. Ashish Mahajan
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Abstract

Our client, Dr. Ashish Mahajan, is a plastic surgeon at UW hospital and routinely transfers patients from the operating table to post operation hospital beds after surgery. The process takes up to six people and is complicated by patients who require anything other than flat bed to flat bed transfer. Patients with upper body or abdominal surgery are commonly required to stay in the semi-Fowler position, where the patient's back is raised and the hips are slightly flexed. This position creates problems for existing patient transfer devices as they are all flat and don't fit well under a patient in this position.

Current Design

Currently, Dr. Mahajan and his coworkers are using a 25" aluminum roller board. The device contains five aluminum rollers, which allow the patient to roll with little friction, and two aluminum rods that tighten the end plates together and creating a solid structure. The main problem with the current design is the lack of flexibility in the structure, not allowing for a wide variety of applications. The design works great for a patient being transferred from one flat bed to another flat bed, but its success any other bed positions is limited. Our client has also used rigid low-friction sliding boards but has expressed that patients generally slide down in using these boards on inclined surfaces.

Figure 1: Current Design
The current model our client is using is a good start to our future design.
Equipstat.com

The aluminum rollers have a calculated thickness of approximately 0.1 inch. This number was calculated using weight, known density and volume equations as the end caps prevented any measurement of wall thickness. The end cap weights were not known but estimated on the light side to ensure the calculated thickness would be a maximum conceivable thickness. The end caps are simply fittings on the end of each roller that allow the roller to fit into the aluminum plates.

Design Requirements

Dr. Mahajan has asked us to design a patient transfer device that can be safely used to transfer possibly sedated patients from an operating table to a hospital bed. Our client is requiring the device to safely move a patient up to 350 lbs. It is important that the device can not only hold this shear weight, but also hold it safely while being used. The device must be lightweight, less than 20 pounds, so anyone aiding the transfer can easily carry it from its place of storage to the patient in need of transfer. Dr. Mahajan has expressed his satisfaction with the simplicity and durability of the current design, so our new design should possess both of these qualities. This product will be used in direct contact with anesthetized patients and for this reason cannot contain any sharp edges, points or other potentially harmful elements. The design must be less than 50 inches in total length, in order not only to be used and stored in cramped operating room conditions, but also for the comfort of the patient being transferred. When the roller boards are too long, they actually hinder the performance of the device, limiting the efficiency of the transfer.

Design Components

Base

We will be constructing the endplates out of 6061 aluminum. This alloy has a good yield strength and hardness. This means that it will not fracture and will hold our maximum weight requirement. We also chose 6061 because it is easy to machine, especially compared to alternatives such as steel, allowing greater freedom for fabrication. Each plate will be 14.5 inches long, 1 inch tall, and a 0.5 inches thick.

The endplates will be connected by two 17 inch aluminum rods. These rods will span the gap between the plates and provide the skeletal structure and strength of our design. Each rod has an outer diameter of 0.5 inches. This diameter is small enough to be lightweight, but is still strong enough to be the fundamental brace.

There will also be five steel bolts attached to each plate. These bolts will fit inside of the ball bearings and support each roller. Each bolt will be 1.25 inches long have a 0.25 inch inner diameter. The end plates will be pre-drilled and the bolts will be countersunk in order to allow for a flush outside surface. This feature will enhance the safety of our prototype by minimizing protruding parts.

Rollers

Each board will contain five rollers that will fit against an end plate. A single roller will be comprised of one piece of aluminum tubing (outer diameter: 1.25 inches, inner diameter: 1.0 inch, 17 inches long, and an alloy of 6061), and two ball bearings (outer diameter: 1.0 inch, inner diameter 0.25 inches). One ball bearing will be press fit into each end of the aluminum tubing, and will rotate around a 0.25 inch bolt.

The thick walls (0.125 inches) and hard alloy provide a suitable strength for supporting a maximum load of 300 lbs. This thickness will exceed the current device's calculated thickness of 0.1 inch. The outer shell of the tubing is completely smooth and will not cause any discomfort to a patient during use. All sharp edges will be filed down prior to assembly in order to ensure patient safety.

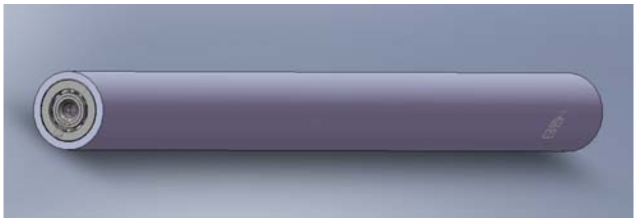

Figure 2: Roller
The device will consist of 5 aluminum rollers, with ball bearings to ensure Dr. Mahajan's patients a pleasant transfer

Ball bearings will allow a smoother transfer than the client's current setup. The bearings that we will use can spin up to 1200 rpm. This far exceeds our needs of 6-10 rpm, but reassures us that these bearings are viable for our prototype. The bearings are also made out of steel and can take a radial load of over 400 lbs. Again this affirms that this portion of our design will also be able to hold our target weight.

Figure 3: Roller Bearing
Our clients patients will arrive in style on these steel roller bearings
Bearings-china.com.cn

Covering

Each board will be covered by a vinyl sleeve. This covering protects the occupant from all the rotating rollers and other metal components. The vinyl cover will also be the only component on our design that needs to be sterilized between uses. For this reason, we must use a material that can be cleaned and not lose strength after washings.

Design Alternatives

Two existing boards

This design alternative consists of two pre-existing boards being connected by two hinges. This requires the least amount of actual fabrication needed for the product to be made, therefore minimizing the chance of error in fabrication.

Figure 4: Hinge Existing Structures
In this design, two existing structures would be hinged together.

This design does have its problems. This alternative is more expensive than just buying the raw materials and building it. Also, if second-hand boards are bought there is no guarantee they will be identical, making attachment of the hinge more complicated. The shortest board we found is 25 inches in length, and two 25 inch boards used in tandem would be cumbersome to those transferring the patient. We decided that 17 inches would be the optimal length for each roller section of the board.

Modification of the two existing boards is a possibility, but it leaves no room for error since there are no replacement parts short of buying another roller board. This would also add more expenses to the already high cost, with an expected cost of around $450.

No Bearings with Integrated Hinge

Another design alternative would be to build a board from raw materials, use a more custom designed hinge and cap the ends of the tubes with inserts to allow them to roll. The hinge would be an extension of the aluminum plate that holds the rollers in place. This would allow the design to be more modular, so the staff can easily remove one board if a single smaller board is desired. This design also has the least amount of parts being used, which means less to build and less to fail. We calculated that this design will be 39 inches in length.

One problem with this design is the waste generated when milling the end cap. A large amount of aluminum would be milled away to create the hinge and the material cannot be ordered in a way to make this process more efficient. Another issue would be the friction caused by the caps in the end cap holes, reducing the efficiency of energy input to transfer patients.. Another potential problem is the amount of wear that could occur from the metal pin in the metal slot.

Bearings with L-Shaped Hinge

The last design alternative is to build the two boards from raw materials, use bearings and an L-shaped hinge. The hinge is the least obtrusive and simplest design available. Ball bearings will reduce friction when in use, so it requires less work to transfer the patient. Wear will also be reduced because of the ball bearings. This design will be 40 inches in length which means it is one inch longer than the integrated hinge. This is a negligible length when compared to the overall length of the roller board.

An issue with this design is the total amount of parts included in the roller board. This should not be a problem, it is only something to consider because our clients likes the simplicity of the current design; though this has very little potential to complicate the roller board when it is finished. Weight will also be reduced because L-shaped hinge requires less material than the integrated hinge.

Design Matrix

In order to decipher which design will be most successful for real world application we created a design matrix that measures various aspects of our designs. These aspects include safety, ease of use, cost, durability, and simplicity. There will be a high interaction between our product and staff and patients alike, and for this reason we feel that ease of use and safety should be given top priority when considering design alternatives. Durability and simplicity rank second and third respectively, followed by cost.

Cost

First, we felt cost shouldn't be the main reason for selecting a design, but it definitely is a factor. While all the designs are going to cost a fair amount design 1 seemed especially inefficient. Buying two boards alone would cost well over our current budget. Design 2 and 3 both consist of purchasing raw materials and making the device from scratch, therefore the cost between the two don't deviate that much. However, this method usually leads to some unused material, which is why neither could receive a perfect score.

Simplicity

Next, simplicity is a measure of whether or not we've overcomplicated the solution to the problem. Connecting two existing boards with a hinge is clearly the simplest solution to the problem. Trying to build two boards complicates things to a greater degree, but trying to also makeshift a hinge is making the problem harder than it needs to be. For these reasons, design 1 is the best, design 2 is the worst and design 3 is somewhere in the middle.

Durability

Third, the current product is very durable; therefore we need a product that is just as durable. The location in each design where a bigger force will be exerted is at the hinge. This is most likely the component that would break down first in any design. However, in both design 1 and 3 a hinge can be replaced no problem, but if the homemade hinge design broke, the whole device would need to be replaced. For this reason design 1 and 3 rank higher than design 2 in regards to durability.

Safety

Fourth, safety is a huge issue with our device because of its purpose. Our design must keep in mind the well being of the patients this device is used for as well as the staff members using it. Design 2 received the lowest score because we aren't completely certain on how well the hinge will interact with the patient. There is a chance that it may pinch the patient. Furthermore, the complexity of the hinge may cause for an excess of sharp corners. Design 1 is safer, but not quite perfect. Using to boards is asking staff to carry, store, and perform with twice as much material. This could be hazardous in a crowded operating room. Also, the device would be too big for the bed, causing the angle of the patients' legs to change. This would be counterproductive towards our goal. Finally, The L-shape hinge design allows for minimal sharp edges, will be easy to store, and will fit just fine on an operating bed. These reasons alone are why it scored the best in the safety category.

Ease of Use

Finally, ease of use is the most important aspect of our device for reasons previously stated. The homemade device got marked down because the hinge would only bend one direction so operators would have to take extra time to figure out the proper way to lay down the device. Furthermore, because of complexity we might just not be able to manufacture a smooth enough hinge for flawless function. Design 1 again gets marked down because of its size. The cumbersome factor makes it harder for staff to carry. When in use, half of the bottom board wouldn't be on the bed. This complicates the use of the design. Design 3 has the freedom of bending in either direction. Its size doesn't complicate its use. Finally, the addition of ball-bearing rollers increases the ease of use of the current design.

Design Matrix:

Design	Safety	Ease of Use	Cost	Durability	Simplicity	Total
Design 1: Two boards with hinge	**22**	**25**	**4**	**20**	**15**	**86**
Design 2: Homemade	**20**	**25**	**7**	**15**	**10**	**77**
Design 3: L-shape hinge	**25**	**30**	**7**	**20**	**13**	**95**

Final Design

From the design matrix it is clear that we should go with the L-shaped hinge design. Our design will consist of five rollers per board, all equipped with ball bearings. These rollers will be attached to aluminum end plates via steel screws. The device will be given support by the two steel rods per board attach end plate to end plate. The L-shaped hinge will connect the two boards together and will not lock. This will allow for the device to be used easily at any bed angle. The overall dimensions of the device will be 40 inches long, 14.5 inches wide, 1 inch high on the end plates, and 1.5 inches high from the rollers.

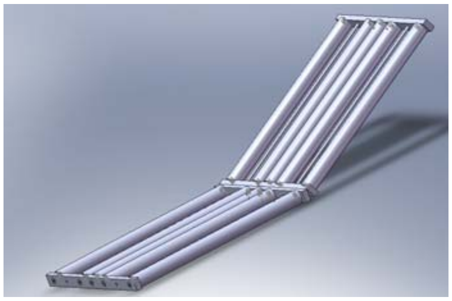

Figure 5: Final Design
The final design offered our client the best features and was also the most affordable

Figure 6: L-Shaped Hinge
The L-shaped hinge is small, lightweight, and reliable.

Ergonomics

This product will be used strictly by medical staff. These users are trained and have used similar devices in the past. User compatibility should not be an issue. This product will provide one advantage for users compared to past devices. We will be installing ball bearings in each roller, making the force required to transfer a patient will be reduced.

We have also designed our product for patients of various heights, 5.0 feet to 6.75 feet, and weight, up to 300 pounds. Patients will also be protected from all rotating pieces via two vinyl covers that wrap completely around the rollers. All sharp corners and burs will be filed down, to avoid injury to patients and operators alike.

Product Design Specifications:
Patient Transfer Device

Team Roles:
Team Leader: Justin Gearing
Communications: Jamon Opgenorth
BWIG: Alex Bloomquist
BSAC: Dan Miller

Last Update: February 6^{th} 2008

Function: Currently, patients are transferred by 5-6 workers using an articulating roller, which is designed for a flat bed to flat bed patient transfer. The client would like a jointed roller system that will allow for efficient transfer of patients who are to remain in the semi-fowler position through the transfer. Design needs to be reliable, lightweight, and compact to fit behind the door of the recovery room.

Client Requirements:

- Must not harm patient or staff members
- Must be simple and easy to use
- Must be cost efficient
- Must be durable
- Must be easy to store

Design Requirements:

- Must be lightweight
- Parts must be easy to replace
- Device must be easy to clean
- Device must be able to be used at various bed angles
- Device must fit effectively under a patient
- Device must be easy to carry

1. **Physical and Operational Characteristics**
    a. **Performance Requirements:** The patient transfer device must be able to transfer a patient from bed to bed, without affecting the position of the patient. This product specifically focuses on keeping the patient in a seated position. This device will be used multiple times each day, with varying weights applied.

b. Safety: There must be no sharp edges on the device which could otherwise harm the patient or operators transporting the patient. The device must also be able to support patients up to 158.76 kg. The rollers and all moving parts must be covered by a vinyl covering

c. Accuracy and Reliability: The product needs to be durable enough to withstand daily use without breaking down. Accuracy is not a factor with this project.

d. Life in Service: Parts should be made replaceable, increasing the service life indefinitely. The product should be able to withstand use multiple times per day.

e. Shelf Life: Storing the product will have no effect on its ability to perform

f. Operating Environment: This device will primarily be used in an operating room. This environment will be room temperature and completely sterile.

g. Ergonomics: The patient transfer device should be able to withstand all human interaction of proper use.

h. Size: The patient transfer device must be small enough to fit beneath the person and on the current holding rack (1.143m x .381m x .0254m).

i. Weight: The weight of the product should be less than 9.07 kg.

j. Materials: Materials for this product must be able to support a load up to 158.76 kg, and be able to rotate with limited friction. Most components will be made of aluminum, along with some steel components depending on the structural stability.

k. Aesthetics, Appearance, and Finish: The patient transfer device should appear safe and operable in order to not scare the patient or operators.

2. Product Characteristics

a. Quantity: One unit will be needed.

b. Production Cost: We have been provided with a preliminary budget of $400, with the option to expand if needed.

3. Miscellaneous

a. Standards and Specifications: No standards or specifications are required.

b. Customer: The customer would like a device that prevents patients from shifting position during transport while seated. He has stressed that durability is a major priority with this project.

c. **Patient-related concerns:** The patient may under anesthetics while this device is used. In this situation the entire weight of the patient will be under control of the operators and patient transfer device.

b. **Competition:** Currently no product exists that meets all of the requirements of our client.

References

www.Equipstat.com

www.Bearings-china.com.cn