Patient Transfer Device

Final Design Report

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Abstract

The goal of our project this semester was to design and fabricate a device that would efficiently transfer sedated patients from the post operation table to a hospital bed. The design had to allow for patients to be transferred while remaining in the semi-fowler position, as certain surgeries require the patient to remain in this position. There are many existing patient transfer devices on the market today, including roller boards, low friction boards, inflatable designs and even motorized patient transfer devices. However, there are currently few devices that are made to accommodate the semi-fowler position. To solve our client's problem, we designed and fabricated a hinged roller board system with ball bearings and a vinyl cover. This system will effectively replace Dr. Mahajan's current board, as it efficiently transfers patients in the semi-fowler position as well as on a flat bed.

Introduction

The main function of a patient transfer device is to assist in relocating a sedated post-op patient from the surgical table to a hospital bed. The current procedure of transferring a patient is fairly simple. First, the hospital bed is pushed next to the surgical bed. Next, a sheet is wrapped around the transfer device. Third, the patient is "log-rolled" on their side and the device is placed under them. A staff member pulls on the sheet that is wrapped around the device and another member pushes the patient. Once the patient has been transferred successfully, they are "log-rolled" again and the device is removed from underneath the patient. This process takes no more than 20 seconds and is done with between four to eight staff members.

The current device that performs this task at the UW hospital is a rigid roller board. Shown in Figure 1, it consists of five rollers that are connected to two endplates. The rollers rotate via bronze pin caps at each end of the rollers. The end plates are connected by two supporting rods that are held together by steel bolts. A vinyl cover is placed over the product to reduce friction as well as maintain the cleanliness of the device. Overall, the device is 30 inches in length, 14 inches in width, and because of the rollers it is one inch high; the rollers are one inch in diameter. Also, the device weighs about 10 pounds.

Figure 1:
Dr. Mahajan's current device is sturdy, safe, reliable and efficient. The designs main flaw is that it is inefficient for use in the semi-fowler position (Universalmedicalinc.com).

This device is preferred by our client over other devices for a several reasons. The current device is very durable; it has yet to break or malfunction in any way in the four years he's used it. It is a very simple, compact design. For this reason, not only is it easy to use, but it is also very easy to store. This is a crucial factor when considering the importance keeping the clutter in the operating room to a minimum. The device is easy to maintain as the vinyl cover can be easily removed and washed. Finally, it is very safe to use. It isn't dangerous for anyone to carry and is safe for patient transport.

Problem Statement

The one major drawback to this device is that it is completely flat and rigid. There are many surgeries that require the patient to be in a bent lawn-chair like position.

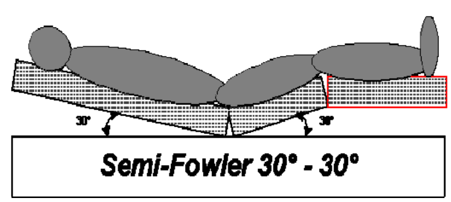

Figure 1: Shown is a patient in the Semi-Fowler position. The hips and upper body are elevated 30 degrees from a horizontal plane (www.decubitus.be).

The most common of these positions is where the bed is at a 30/30 angle (as shown in Figure 2). This is known as the semi-fowler position. When a patient needs to remain in this position after surgery the current transfer device makes it especially difficult to transfer the patient. Since most of the patient's weight distribution lies on both sides of the fold in the bed, there is no way for the current device to support both the patient's lower back and thigh area (areas of high weight distribution). Therefore, it became our task to create a new device that would accommodate the semi-fowler position, or any other bed angle, by providing support to both areas of greater weight distribution.

Design Criteria

From talking with our client, we wanted to incorporate as much of the beneficial qualities the old device had into the new device. This meant we wanted our device to be simple, safe, durable, cost effective, and easy to use. To make sure we met these needs we set up specific criteria for our device to be measured against. First, the design needed to be light weight and easy for one person to carry. Therefore, the final design shouldn't weigh more than 20 pounds. Second, length of the board is important as it is related to the weight of the board, how easy the device is to use, and how easy it is to store. A reasonable length was no longer than 1.5 times the length of the current board (no longer than 45 inches). Third, our design needed be more efficient than the current device. Two ways of measuring this are making sure the device works at any bed angle (including flat), and testing to see if there is a decrease in force required to move our design versus the old design. Fourth, to ensure safety, there could be no sharp corners or protrusions. Also, the device absolutely needed to support a load of at least 300 lbs. We also needed to stay within a budget of 400 dollars. Finally, all parts used for the design need to last no less than 10 years or be easily replaced.

Background Research

Besides looking at our clients current design model, we wanted to see what else was available, so we searched designs and patents. We searched the uspto.gov to find what designs had already been patented. There were many alternatives found to the current design, but not many solved the problem of the fowler position.

EZ Matt

One interesting design was an inflatable mattress (Figure 3) that is already under the person, inflates, and then deflates after transfer. This product is known as the EZ Matt (EZ Way Inc., 2009). This is problematic as the mattress wouldn't bend properly. Also, extra equipment is required to inflate and deflate the mattress. This causes clutter in the operating room. Overall, this device is an innovative design, but falls short in several of the design criteria for our patient transfer device.

Figure 2: EZ Matt is shown deflated. The various components shown at the top are needed to inflate the mattress. (EZlifts.com).

Suspended Chair Patent

Another design that could potentially solve our client's problem is the suspended seated chair apparatus (Figure 4). This device works by sliding foldable parts of a chair under a patient. The patient is then secured by safety cords. The entire chair is attached to a base framework on wheels. The patient can then be moved by the entire apparatus and placed in a new bed (Merry, 1991). Major problems with this device include

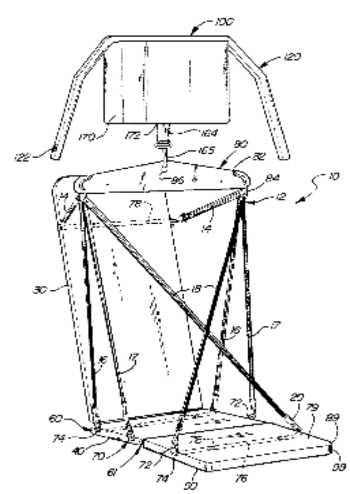

Figure 4: Sketch of suspended chair patent. Framework and wheels are not shown (Merry, 1991).

its complication, it causes a lot more work for staff, and it isn't easy to store.

Allen Board

One final design that Dr. Mahajan described to us is a product known as the Allen Board. It is a thick mat that could fold up and has a frictionless sheet surrounding it (Figure 5). It works the same way as the current roller-board device, but without the rollers. This device seemed like

Figure 5: Allen Board. The exterior blue covering provides the function of the device by being frictionless (AliMed.com)

an optimal solution to his problem, however, the frictionless sheets must be disposed of after use and extremely expensive ($126.00/ 50 sheets). This results in the product being very cost inefficient, which would not be appreciated by our client (A. Mahajan, personal communication, Jan. 27, 2009).

Based on our research and from our brainstorming session we found that it would be in our best interest to keep our design similar to the current design. The major changes that we would make however include adding a hinge to connect two smaller boards together. Also, add ball-bearings into the rollers to reduce the amount of effort needed to transfer a patient. The hinge and ball-bearings are just a couple of components that make up the final design.

Dimension Research

We also did some research to discover the proper length for a hinged roller board. In order to create the most efficient board length possible for the average patient, we had to a bit of surveying. We gathered several people and took two measurements to help formulate the proper length. The first measurement was taken from the base of a chair (while subject was seated) to the base of the subject's shoulder blades. This measurement was taken to help determine the ideal length for the roller board that would lie under the patients back. The second measurement taken was from the hip down to the knee, in order to determine the proper length for the roller board for the patient's lower body. Through these measuring methods, we found the ideal lengths for the boards were nearly identical. Instead of having two nearly identical, but different lengths, we decided to fabricate both boards the same length. This would help with the ergonomics of our device, by simplifying the staff's job when needing to decide how to use the device to transfer a patient.

Preliminary Designs

Two Existing Boards with Hinge

The first preliminary 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 of our three alternatives, therefore minimizing the chance of error in fabrication. This design does have its problems, as it is more expensive than

Figure 6:
The two existing boards design would simply link two boards with a hinge in the middle. The final product would look very similar to this figure.

just buying the raw materials and building it. Buying pre-existing boards would also significantly limit the amount of flexibility that we have to choose ideal dimensions and create the best design. For example, if we decide a certain hinge would be the most efficient, but we cannot implement it with two existing devices, we must change the hinge. If we fabricate everything ourselves, it would allow for modifications to the design of the roller boards to accommodate the best hinge design. 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.

This design alternative would have the highest cost of the three. Buying used roller boards online would allow us to complete this design for around $450. This is slightly higher than our client's budget of $400.

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

Figure 7:
The integrated hinge design would have a pin and hole assembly allowing for easier fabrication. However, this would increase the amount of friction and reduce the efficiency of the transport.

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. This would drive up the cost of this design alternative with little to show for the extra money spent. Another issue is friction caused by the caps in the end cap holes. There would be pins sticking out of each roller that would sit in holes in the end caps, allowing for an incredibly simple articulating roller (Figure 7). However, because this alternative uses no bearings or other alternatives to reduce friction, it would require the most work to transfer patients.

Bearings with L-Shaped Hinge

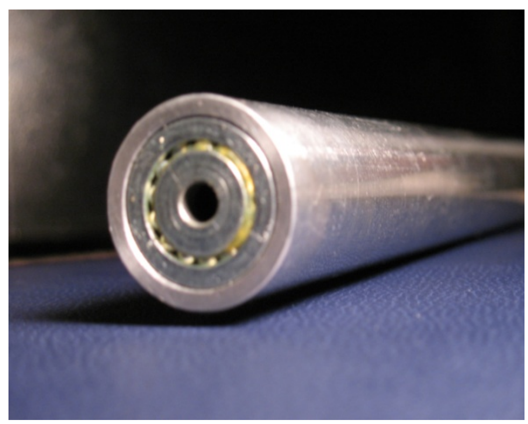

Figure 8:
Steel ball bearings would be placed in both ends of each roller. This design would have the most efficiency of transport energy.

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. Like the other designs, this design alternative will incorporate two separate roller boards, and integrate them with a simple hinge. Ball bearings will be placed in all of the aluminum rollers, providing the design with reduced friction, so it requires less work to transfer the patient. Adding bearings in the rollers will also reduce the amount of wear between parts in significant frictional contact, thus increasing the shelf life of this alternative. This design will be 40 inches in length which means it is one inch longer than the integrated hinge. The amount of parts is something to consider with this alternative as our client has stressed his satisfaction with 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.

Final Design

The Patient Transfer Device prototype, shown below in Figure 9, is used to transport sedated patients that cannot move themselves to an adjacent bed. It accomplishes this task by using rollers and a belt as a type of treadmill to move the patient. This same technique is used to move large, heavy objects from place to place. The Patient Transfer Device works correctly with the beds in the flat and the semi-fowler position, along with any position in between. This is due to the articulated board. It has a hinge in the center that allows it to accommodate any angle from approximately -90° to 90°.

The final design has four major components: rollers, end caps, connecting rods, and L-hinges. The connecting rods hold the end caps together and provide the torsional rigidity of the roller board. The end caps in turn hold ¼”-28 Allen screws in place that hold the rollers in place. The L-hinges hold the two identical roller boards together in the center. All these components work together to transfer the patient easily, safely and quickly.

Figure 9:
This figure shows the final design without the vinyl cover. It is easy to see how all of the individual components come together in this view.

Materials

The Patient Transfer Device was made entirely of 6061 aluminum with the exception of ball bearings, nuts, bolts and washers. 6061 aluminum was chosen for a number of reasons. First, 6061 is one of the most affordable aluminum formulations and most readily available. Since it is affordable and easily accessible, the design can be reproduced faster and more affordable than most other materials. 6061 is also a very easily fabricated material that allows drilling, tapping, milling, and lathe work to be done faster than with a harder material. Another reason for choosing 6061 is the fact that it is very lightweight. With a density of 0.098 lb/in.^{3} it resulted in our final product being slightly less than 15 lbs which is well within our 20 lb limit.

The nuts, bolts, and some washers of the Patient Transfer Device are steel. Steel was chosen because these components were such a small portion of the design that weight would not be significantly affected. The steel components are so readily available, cheap, and strong that there were no other competitors.

The neoprene was selected for the material of the spacers at the end of the rollers for a number of reasons. Neoprene is compressible material that returns to its shaped very well after its shape is changed. This is an excellent attribute because the spacers need to keep the rollers off of the end cap and stop the rollers from bouncing between the end plates, which means they are constantly compressed.

Rollers

The rollers of the Patient Transfer Device are aluminum tubes that bear the brunt of the weight from the patient. Due to this consideration, the 17" tubes have 0.125" thick walls and are extremely strong. 0.125" was the chosen dimension for the wall because we did not have access to the wall thickness of the previous design model and we wanted to keep the roller board safe, so we chose to keep the rollers on the thick side. A small lip 0.28" deep was lathed into the inside of each end of the rollers. This was for the steel ball bearings, shown in Figure 10, to sit and to prevent them from

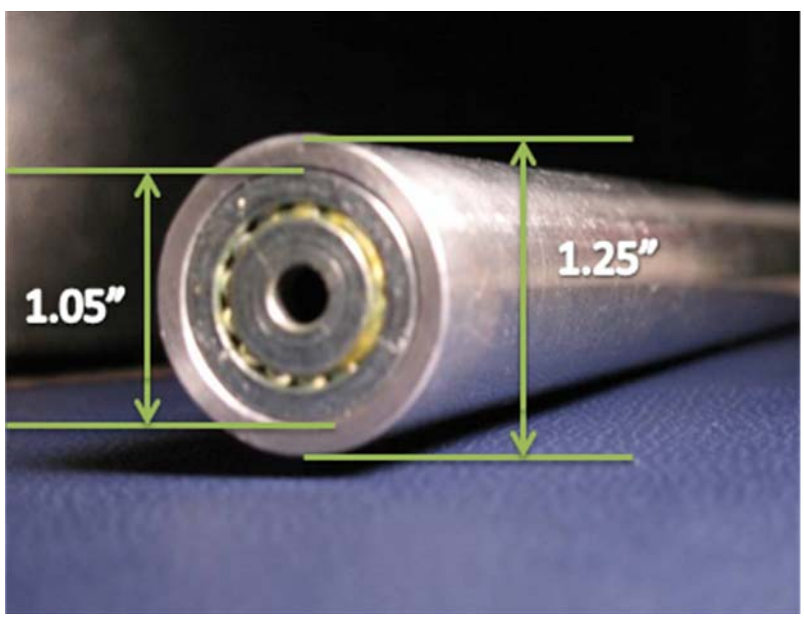

Figure 10:
The aluminum rollers have steel ball bearings press fit into each end. This allows for significantly easier patient transport due to reduced friction. Not shown here, the inner diameter of the bearing is 0.25".

falling any farther into the tube. Loc-Tite was used to secure the ball bearings further in order to ensure easier assembly and disassembly. The tubes are 1.25” in diameter in order to make sure they protrude both sides of the end cap. This is to ensure that the patient’s weight is indeed on the rollers and not on any edges. There are a total of 10 rollers in the roller board in order to distribute the weight over an adequate amount of area.

End Caps

The end caps of the roller board play a very large part in keeping it together. They are 1” x 0.5” x 15” aluminum blocks and play a variety of roles in the product. They each have five ¼-

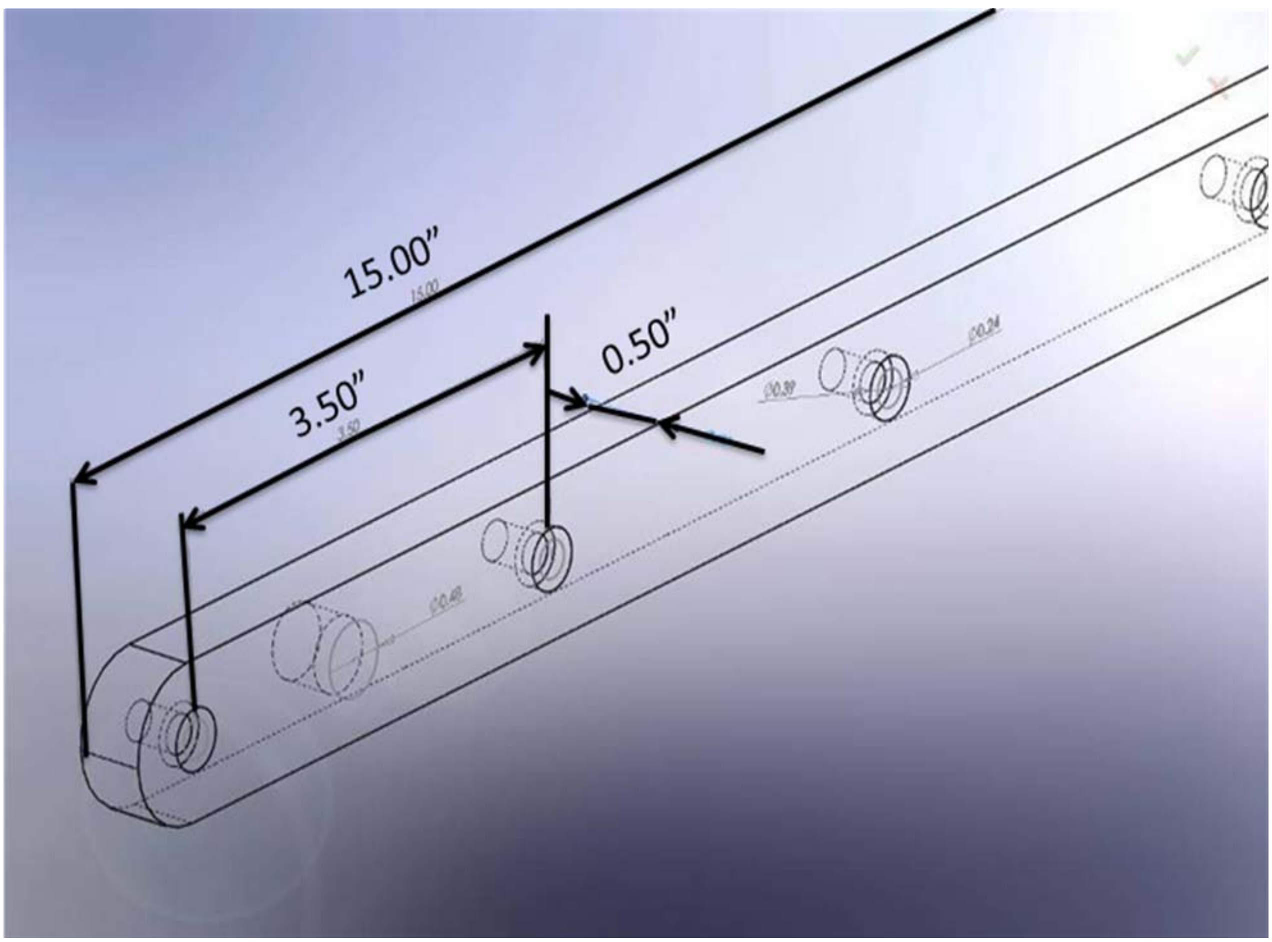

Figure 11: End Cap
SolidWorks model of the final design end plate. This view shows the countersunk holes drilled for our bolts as well as the larger hole for our aluminum rods that create the structural integrity of the device.

28 Allen bolts screwed through, each 3.50” apart. These bolts enter the inside of the ball bearings of the rollers and support them. 3.50” was chosen because it provides consistent support for the patient throughout the transfer, not sacrificing support in any area. This also keeps the roller board symmetrical. A 0.6” neoprene washer sits on the Allen bolt in between the bearing and end cap in order to prevent the roller from contacting the end cap. The washer is sufficiently small in diameter to prevent it from rubbing the outside portion of the bearing. The Allen bolt heads are also countersunk 0.15” to remove from the bulkiness of the end cap. They can be countersunk because the major force on them would be a shearing force, so depth makes very little difference. The connecting rods are also inserted into the end caps. The end caps were fabricated using a standard drill press at the UW-Madison College of Engineering Shop.

Connecting Rods

The connecting rods hold the two end caps they are paired with together. The rods are solid aluminum and 0.5” in diameter. This allows drilling and tapping, with a lathe, on the ends and due to its small diameter, and does not add much weight. They are inserted in to a 0.22” deep hole on the end cap. This hole provides the roller board with its torsional rigidity. They are connected to the end caps using two ¼”-20 Allen bolts on the non-hinge side and two ¼”-20 hex bolts on the hinge side. The hex head has less profile than the Allen head, which proved to be a necessity when assembling the hinge.

Cover

The cover helps smooth the delivery of the patient and has other useful function. It is made of vinyl sewn in a cylinder with a circumference that allows it to fit onto the roller board as well as be tight. The cover prevents foreign objects from entering and damaging the roller board as well as preventing sheets from snagging on the rollers. The vinyl is also an easy to clean surface that helps with sterilization. Though it is probably the simplest part of our design, it has a wide range of uses.

L-Hinge

The L-Hinge is what makes this design such an improvement on the past designs. It is very simple angle aluminum cut 1" wide. The angle aluminum is 0.13" thick and has a length of 2" on each side of the 90° angle. One side is cut to 0.9" and the other is left at 2". Two holes drilled on the long side are used to fasten it to the end cap with ¼-20 hex bolts. The short end, shown in Figure 12, is rounded to ensure the hinge does not come in contact with the opposite endplate. When the L-Hinge is attached to the end caps, one end cap has the hinges mounted 0.2" farther apart than the other in order to allow them to fit together. A nut, bolt and two washers are used to hold the hinges together, thus completing assembly.

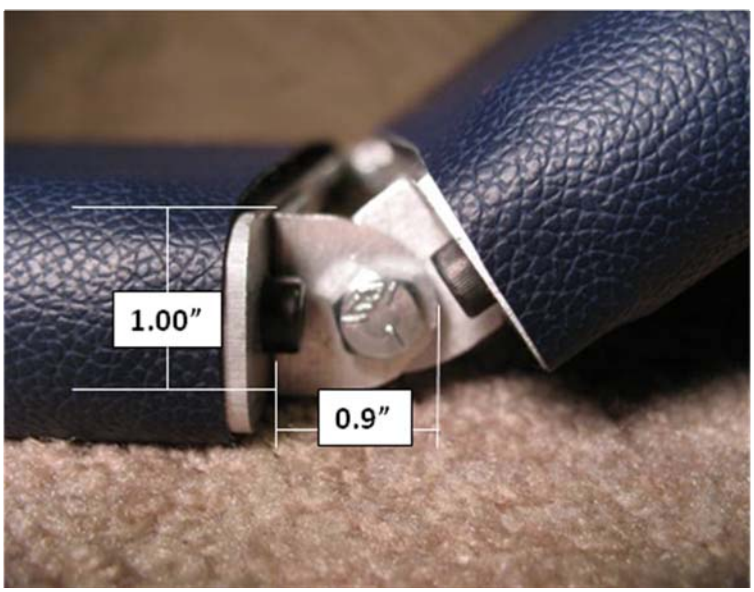

Figure 12:
The L-Hinge allows for bi-directional rotation about the center. The major complication with this hinge design was making it small enough not to encumber patient transfer.

Maintenance and Proper Use

The patient transfer device was designed for use in positions similar to the semi-fowler position as well as use on a horizontal bed. It is crucial that the device is only used as intended, for transferring patients by trained medical staff and not used for any other purposes. All bolts should be regularly checked to ensure that they are all snug and will not loosen during patient transport. Failing to check bolts could result in inefficient transfer or even failure of the device while in use. The vinyl cover should always be in place during patient transfer. This keeps the patients protected from all moving parts of the patient transfer device, and also allows for an easy-to-clean surface for medical staff.

Figure 13:
Lock nuts or washers must always be used on hinge bolts (green arrows).The bolts (purple arrows) that fit into the aluminum rods can be variably tightened, but should never be left loose enough that they could possibly fall out.

If the two ¼”-20 bolts that make up the hinge (Figure 13) are ever replaced, loosened or removed for any reason, it is imperative for the long term performance of this device that the bolts be securely re-fastened with a lock-washer or lock-nut. With the constant hinging of the device, the nuts will slowly loosen over time if these are not present.

The bolts that tighten into the aluminum rods that give the device its structural integrity, shown in figure 13, should be tightened regularly to ensure that the device remains safe for patient transfer. These bolts can be tightened or loosened to a varying degree, though it is imperative for safety reasons that the bolts are tight enough to just slightly impair rotation of the rollers. Over tightening of the bolts will reduce the effectiveness of the ball bearings and require more force to move patients. If the boards are ever disassembled for any reason, they must be assembled with attention to detail and common assembly logic. For example, the aluminum rods should be tightened evenly from all four points (four bolts on each roller board), instead of completely tightened from one side and then only minimally tightened from the other. This is to ensure proper functioning of all components of the patient transfer device.

Testing

Design Specifications Verification

At the beginning of this project we defined design specifications in order to meet the goals of our client. The two quantitative specifications we defined were: the product must weigh less than 20 pounds and the product must hold a 300 pound load. We weighed all the components of our product and it totaled 14.9 pounds. We then loaded both boards (individually) with 315 pounds and there were no signs of deflection with the load. Following the test, we inspected for bending and other signs of stress damage. There were no cracks, bends, or other visible differences.

Safety was another design goal. The specification defined safety as having no sharp edges, corners, or other safety hazards. We conducted an inspection by running a finger down each edge and corner. Two team members conducted this test. Neither member felt discomfort while performing this test. There was also a visual inspection for pinch points and other safety concerns. It is possible that the hinge could potentially pinch fingers and other body parts. Therefore caution should be taken while carrying the device and changing the angle of the hinge. Besides this one safety issue, there are no other safety concerns that would affect the patient or operators of the device.

Performance Testing

By adding roller bearings to each roller, we increased the performance of our roller board compared to the previous model. We tested this by placing a 150 pound load one of the new roller boards. We then measured the required force to move the board from a static to dynamic state. Five trials were conducted on both of boards, the non-hinged model and our new product. Our study proved that our design required statistically significant less force than the previous model. The average force required in our model was 1.8 pounds (standard deviation of .274 pounds) and the old model required an average force of 5.5 pounds (standard deviation of 0.500 pounds). Other two variable statistics are shown in the Table 1. Chart 1 is a visual representation of our results from this test, displaying the average force and standard deviations.

Testing Summary

Groups	*Count*	*Sum*	*Average*	*Variance*	*St. Dev.*
Old Device	5	27.5	5.5	0.25	.5
Patient Transfer Device	5	9	1.8	0.075	.2739

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	34.225	1	34.225	210.6154	4.98E-07	5.317655
Within Groups	1.3	8	0.1625			
Total	35.525	9				

Table 1: Force Testing-ANOVA Statistical Analysis:
ANOVA statistical analysis was conducted on the testing two data sets we found to determine the significance of the standard deviations. This data proves that there was a statistically significant difference between the mean data for the old design vs. our new design. A p-value of 4.98e-7 means that there is a 4.98 in 10 million chance that this data was found from chance alone.

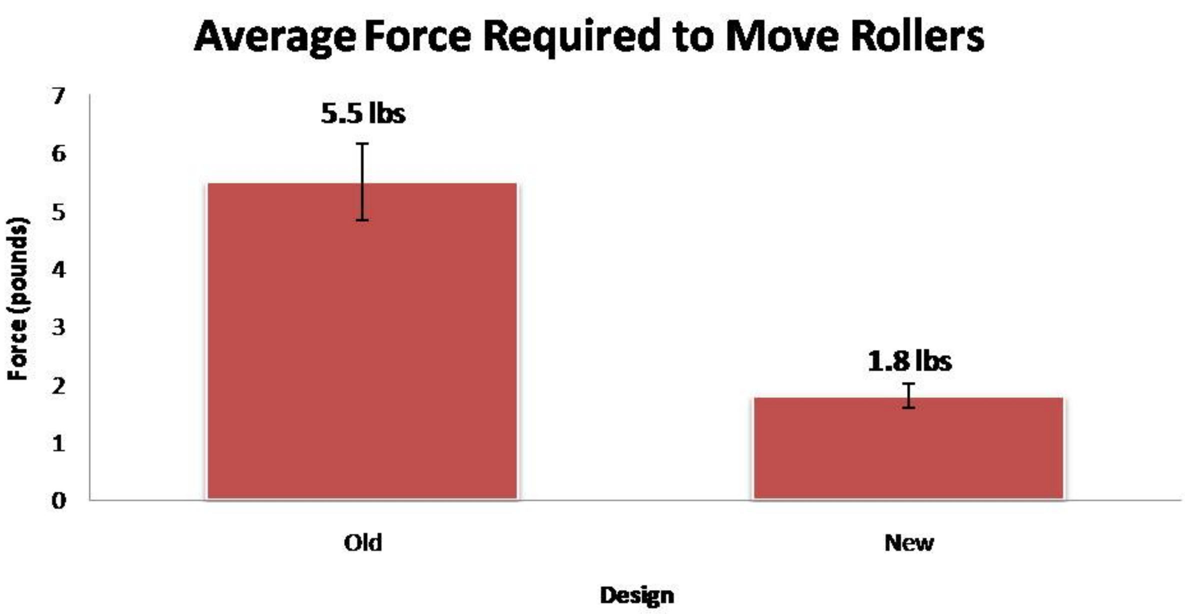

Chart 1- Force Graph:
Graph of average force needed to move 150 lbs at a constant speed. Five measurements for each device were taken showing a statistically significant difference in the average force needed to transfer a patient (p-value = 4.98e-7). Our device reduced the force needed to transport a patient by 67. 28% over our client's previous device.

We also tested the device under real conditions, with our client, at the University of Wisconsin Hospital. The typical post-operation patient transfer procedure was performed approximately ten times. Teammates acted as the unconscious patient and as hospital staff. Following these ten trials the following results were found: no catching or destruction of bed sheets, no loose components, no signs of visible wear, no discomfort to the patient or staff, and reduced ease of use. The product performed flawlessly in the appropriate setting. The client was also visibly satisfied with the result and plans to implement it into further use.

Ergonomics

Ergonomic concepts were strongly considered in the design of this product. The patient transfer device has continual human interaction with two groups of people: hospital staff and patients. The following paragraphs outline the ergonomic benefits that our product offers.

Safety

As previously stated in the testing section, our team conducted a rigorous inspection of our final product for safety hazards. The only hazard found was the possibility of pinching an appendage between the roller boards. Therefore hospital staff should be cautious in carrying or changing the angle of the device. This is not hazard for a patient, who will have their arms across their chest during a transfer.

All corners and sharp edges were filed and grinded down following machining. This prevents cutting and scraping. The use of neoprene washers also creates a tight fit with the bearings and all other components. This will prevent pinching and other injuries from both patient and staff. As an added precaution, vinyl covers protect all rotating components from the patient and staff.

This product will store in the same location, being able to hang on a hook system. This will keep minimal clutter in the operating room and prevent staff members from stumbling. This was a desire of our client.

Comfort

The patient transfer device is comfortable for both patients and hospital staff. The old device currently hangs on hooks behind the operating room door. The device's light weight, 14.9 pounds, makes the device easy to carry. There is also no disassembly required, so all of the components can always stay connected.

While the patient will typically be unconscious during transfer, our device will be more comfortable than alternative devices. The two board system provides a better distribution of weight, because each board will effectively take half of the patient weight. The device can also fold into the semi-fowler position, also allowing for a more comfortable transfer.

Ease of Use

One of our main design goals was to keep the design simple and easy to use. We feel as though we have accomplished that by creating a symmetrical product. Each roller board is identical and can be used as either the back support or leg support. The hinge is bilateral, so it can be implemented effectively on either side.

Hospital staff members, who have used similar one board products in the past, should have no issues to adapting to our new system. The device was specifically designed so that it could be implemented into the existing transfer procedure. As mentioned before, it can still be stored in the identical place.

This hinged product serves as a dual purpose. It efficiently transfers patients in the semi-fowler position. The device can also transfer patients in the flat position, with a reduced amount of required force. This means that our device has the potential to effectively replace all current single, flat roller boards.

We don't anticipate any of our fabricated pieces failing, but there is always the potential for lost or broken bolts or nuts. This product was designed to have replaceable parts, and to aid in this replacement, each bolt on the entire design has a thread size of .25"-28. A list of purchased components and their supplier will be given to the client to aid in finding replacement components.

Performance

The testing that was conducted on this product proves that our product works in an applied setting and is ready to be implemented into use. The addition of the roller bearings and a bilateral hinge improves our patient transfer device compared to existing models. This product requires less force to move from static to dynamic states (see testing results above). The hinge provides allows patient transfer to occur safely in any hospital bed position. This is an improvement from previous devices that only allowed single position transfer.

Aesthetics

The main goal of our design was functionality; however, we feel that our design is aesthetically pleasing as well. All scratches, marks, and writing have been removed from the aluminum. Aluminum pieces have also been polished to provide a lasting shine. Each bolt has been counter sunk to make each plate look smooth. The slim design and color coordination between aluminum and navy blue cover create a pleasing visual appeal. Aesthetics may be minimally important in the performance of this product, but they could potentially aid it the mass marketing of this patient transfer device.

Ethical Considerations

There were several areas for ethical consideration throughout the process of designing, constructing, and testing our product. Teammates were used to test our product before it was used on actual patients at the hospital. The patient transfer device was made with the intent that it can be safely used by any person with a need to use this product. Client money was spent ethically, only on materials needed to complete the project, and price comparisons were conducted. The cost and amount of maintenance of our device by our client was also considered. A complete bill of materials is located in the Appendix of this design report. Ethical issues were limited with this design, but in the areas of patient safety and client relations we feel that we successfully completed an ethical design.

Future Work

We are pleased with the outcome of our design process, fabrication, and final product. Based on preliminary comments, we expect this prototype to be used in an operating room setting. However, there is some further work we would like to employ in order to improve the product.

During testing, our client and members from our design team acted as hospital staff and patients in an empty hospital room. The most useful performance test would be to observe our product being used under real conditions, with hospital staff, an unconscious patient, and in an operating room. The staff's opinions would serve as useful guidance to make necessary improvements. We also had a limited amount of time to test the product, and therefore only conducted approximately ten transfers. Since this device will be used once or twice a day, it would be useful to know how the design and components maintain functionality over time. All of the components were chosen because of their durability, but only real application over time can provide accurate answers.

Based on our own analysis we would like to improve the hinge. Currently the hinge allows rotation from 180 degrees to 90 degrees (and in the opposite direction). Our client only needs the device to hang flat behind a door, therefore the hinge meets his requirement. If this product were to become a marketable product, we would like the device to be able to fold up on itself, so that it could be stored in a cupboard or under a bed easier than this prototype.

Cutting the weight is another mechanical altercation we would like to apply. Due to limited time in research, we chose a tubing thickness that we knew would hold our design specification of 300 pounds. However, we now believe that a thickness of .125 was a bit excessive. Computational computer analysis would provide us with the optimal thickness in aluminum tubing to be light weight and still hold the required load. Using high impact plastic as a material could also serve as an alternative to aluminum while also reducing the product weight. This would also allow for extremely easy cleaning of the entire device after use.

To make this device a competitively priced against current models, the manufacturing time would need to be streamlined. The fabrication of this device took nearly 70 hours. After that initial step the repetition took comparatively less time. The knowledge we gained through machining and researching quicker fabrication methods (CNC mill), we believe we could streamline manufacture time to approximately 40 hours instead of 70.

Appendix

References

http://www.universalmedicalinc.com/patient-transfer-roller-board/detail/QR904_590

http://www.ezlifts.com/products/product_details.cfm?ProductID=27

http://www.decubitus.be/richtlijnen/nl/houdingen.htm

http://www.alimed.com/ProductDetail.asp?style=933279&fprd=Allen%26reg%3B+Patient+Transfer+Board&oid1=&oid2=

EZ Way Inc., (2009). EZ Matt. Retrieved Feb 10, 2009, from EZ Way, Inc. Web site: http://www.ezlifts.com/products/product_details.cfm?ProductID=27

Merry, Donald D. 1991. Patient chair suspension assembly. U.S. Patent 5,038,425, filed September 13, 1990, and issued August 13,1991.

Type	Dimensions	Supplier	Quantity	Unit Price	Total Price
Aluminum Tubing	6'x1.25" ODx.125"	Discount Steel	3	$16.13	$48.39
Aluminum Plates	14.375"x2.75"x1.00"	Discount Steel	1	$31.07	$31.07
Aluminum Rods	6'10"x0.5" OD	Discount Steel	1	$10.13	$10.13
Ball Bearings	0.25" ID, 1.0" OD	McMaster-Carr	2	$3.88	$7.76
Ball Bearings	0.25" ID, 1.06" OD	McMaster-Carr	20	$4.76	$95.20
Vinyl	3'x3'	Joanne Fabrics	1	$10.00	$10.00
Machine Bolts	1/4"-28	Ace Hardware	20	$0.45	$9.00
Bolts	1/4"-28	Ace Hardware	2	$0.14	$0.28
Washers	0.25 ID	Ace Hardware	20	$0.70	$14.00
Lockwashers	1/4"-28	ECB Student Shop	2	$0.20	$0.40
Steel Wool		ECB Student Shop	2	$0.25	$0.50
Shipping			3	$4.95	$14.85
Poster			1	$43.75	$43.75
				Total	$285.33

Table 2: Bill of Materials- This table represents a detailed representation of our bill of materials. Excluding the poster, the raw materials cost $241.58, and all materials for this project cost $285.33.

Product Design Specifications:
Patient Transfer Device

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

Last Update: May 7, 2009

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 a sitting up or "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
- Vinyl cover must be able to be sterilized after each use
- Device must be able to be used at various bed angles (0^{o}-75^{o})
- Device must fit effectively under a patient

- Device must be easy to carry by a hospital staff member

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 the semi-fowler 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 300 pounds.

   c. **Accuracy and Reliability:** The product needs to be durable enough to withstand daily use without breaking down. The product needs to accurately conform to the angle of each bed.

   d. **Life in Service:** Parts should be made replaceable, increasing the service life indefinitely. The product should be able to withstand 1-2 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 aseptic.

   g. **Ergonomics**: The patient transfer device must be safe to patients and operating staff. It must also be comfortable to carry for staff, and comfortable to sit on for patients. The product must be easy to use, therefore there should be virtually no learning curve for hospital staff. The performance of the device should be as good or improved from the existing one board roller.

   h. **Size:** The patient transfer device must comfortably fit under the patient. The product should be easy to carry for all staff members. It must be stored on a holding rack in the OR. We believe the proper dimensions to fit all of these criteria 45” long x 15” wide x 1.5” thick.

   i. **Weight:** The weight of the product should be less than 20 pounds.

j. Materials: Materials for this product must be able to support a load up to 300 lbs, and be able to rotate with limited friction. Components will be made of aluminum, along with some steel bolts.

k. Aesthetics, Appearance, and Finish: The patient transfer device should appear safe and operable. The product should also look professional and marketable.

2. Product Characteristics

a. Quantity: One unit will be needed. Further research will be conducted to determine if surgical staffs are in need of similar devices.

b. Production Cost: The raw materials cost $241.58. The total fabrication time was approximately 75 hours.

3. Miscellaneous

a. Standards and Specifications: Every bolt on the device has a thread size of ¼”-28. All bearings, bolts, and washers can be replaced if needed.

b. Customer: The customer would like a device that prevents patients from shifting position during transport while seated. He has stressed that safety, durability, and ease of use are major priorities 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 there are no hinged roller boards on the market that meet the requirements of our client.