Leg Positioner to Facilitate Placement of Femoral Venous Catheter

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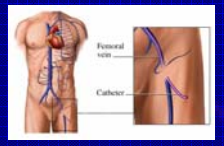
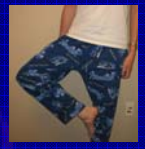
Background

Motivation

Insertion of a femoral vein catheter is common in procedures where access to a large blood flow or a clear pathway to the heart is desired. Catheter insertion can be a difficult process because the femoral vein makes several turns before meeting the inferior vena cava. To facilitate the placement of the catheter, the patient's leg must often be placed in an optimal position that allows for easy access to the femoral vein. This position is often difficult to maintain during surgery and additional assistance is required, typically from a nurse or resident physician. A leg positioner device would eliminate the need for additional personnel, both saving money and reducing congestion in the operating room.





Figures 1a & b: The anatomy of the femoral veins and position optimal for catheter insertion.

Femoral Vein Catheterization and Leg Position

The femoral vein is located medial to the femoral artery and distal to the inguinal ligament. The placement of a catheter can be difficult due to the natural curvature of the femoral vein. In order to straighten the S-shaped path of the femoral vein, the leg of the patient is adjusted so that the hip is abducted and externally rotated and the knee is flexed (*Figure 1*). This positioning of the leg allows for easier placement of the central line.

Client's Expectations

To construct a leg positioner designed specifically to:

- Secure a patient's leg in the optimal position for placement of a femoral vein catheter
- Retract a patient's pannus to keep the operating area clear of obstructions
- Be disposable
- Not interfere with operation field
- Inhibit leg from moving
- Provide attachable device for pannus retraction
- Not slip or rotate

Current Products

Currently, there are several competing products for both positioning the leg and retracting the pannus.

- Manual method
  - Ineffective based on client concern
- Patent #3,931,654
  - •Free moving apparatus on surface, not suitable for stabilization
- US Pub. #2006/0180158 (Figure 2)
  - •Not integrated with potential leg positioning system
- •Leg positioner for saphenous vein harvesting (1997)
- •Siegel MAST Intraoperative Leg Positioner (Figure 3)
  - •Stabilizing base in inadequate position for operation on patient

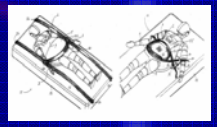


Figure 2: Device for retracting a patient's pannus US Pub. #2006/0180158

Figure 3: Siegel MAST Intraoperative Leg Positioner

Abstract

The goal of this design project was to design a leg positioner that secured a patient's leg at an angle that optimized a physician's ability to insert a femoral vein catheter. Currently there are several leg positioners available for that are designed for specific orthopedic procedures, but none designed for maintaining the leg position needed for a femoral vein catheterization. The design, as of this date, allows for the ability to secure a patient's leg as well as retract the pannus if needed.

Our Design

Preliminary Design

- •Rod able to extend into the weight plate to accommodate the length of the patient's leg
- •Leg cuff on a ball and socket hinge allowing it to move to the designated angle for leg positioning
- •Pannus retractor allowed to adjust angle of away from the field of operation

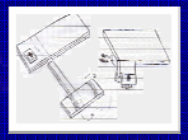


Figure 4: Preliminary design of the leg positioner

Final Design

- All components constructed from high density polyethylene
- •Quick release locking bolt used for quick and easy cuff adjustments along the rod
- Dovetailed rod positions leg horizontally
  - Track runs the length of the bottom board
  - Able to position either leg
- Stationary ground clamp and cuff fixes leg angle at 35º
  - Cuff attaches to calf via Velcro straps
  - Slides up and down the rod to adjust hip and knee angles
- Removable post and retractor restrains pannus
  - Pannus retractor inserts on either side of board
  - Adjusts vertically for variation in patient size

Figure 6: Our design showing pannus retractor and leg rod attached to the bottom board.

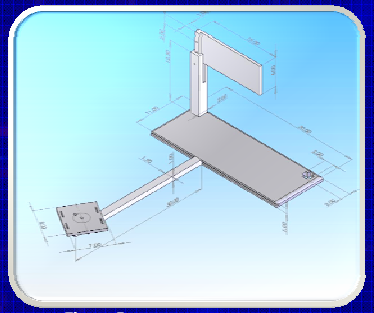


Figure 5: SolidWorks drawing of the leg positioner with pannus retractor

Testing the Design

- •Positioner must be able to accommodate a large range of patient sizes. Ten students were tested, and their height, weight, and hip and knee angles were recorded
- •Results indicate a consistency with hip angle measurements for all tested heights, as well as data for both angles falling into client specified ranges

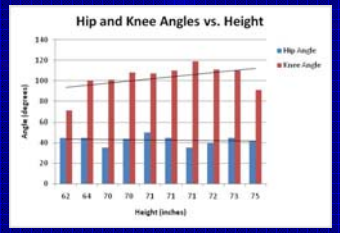


Figure 7: Quantitative analysis of prototype: measurement of hip and knee angles

Conclusion

We met all our client's requirements with the exception of an angled pannus retractor. We did not angle the pannus retractor because we did not have adequate machinery to reduce the thickness of the HDPE plastic. The way our design was envisioned, the angle of the retractor would have fit into a small grove in the post of the pannus retractor; however, there was not enough room for this to occur considering the size of our materials.

Despite this, we were still able to accommodate for patients with either of their legs amputated with the dovetailed sliding rod, fixed-angle cuff, and ambidextrous pannus retractor. Based on our testing, we were also able to match our client's desired lower extremity angles of 45º-60º for the hip angle and 100º-135º for the knee angle, with secured angles of 45º and 100º, respectively. Further testing in the hospital is necessary to fully determine how the well design facilitates the placement of a central venous catheter.

Figure 8: Pannus retractor is not angled and could obstruct surgeon's view during operation

Future Work

- Angling the pannus retractor to position the stomach away from the site
- Improve stability of rod connection system
- Increasing disposability:
  - Eliminate ground clamp to attach the cuff to the rod
  - Make the base plate porous to decrease weight and cost
  - Injection-mold the plastic parts to eliminate screws and pieces
- Human subjects testing

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