DEVELOPMENT OF A MEDICAL SUPPORT GARMENT FOR A PATIENT WITH GIANT OMPHALOCELE: A CASE STUDY

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A new prototype for a medical support garment for an 8-year old patient with giant omphalocele was developed in order to help lock the position and restrict the movement of the omphalocele during daily body activities. Design criteria were based on patient’s specific condition. A custom dress form fabricated to replicate patient’s body shape facilitated garment’s development. Three fitting prototypes were developed and fitted to the patient before a final prototype featuring an open-top pouch lifted by a complex system of straps supporting the omphalocele was presented for wear testing. Feedback from caregivers and patient informed the design decisions.

INTRODUCTION

An omphalocele is a birth defect with estimated incidence of 1 in 6000 live births (Lee et al, 2006), where abdominal organs herniate into the base of the umbilical cord. Omphaloceles can range by size from small to giant, some researchers defining a giant omphalocele as a protrusion with diameter > 5 cm at birth (van Eijck, 2011), while others consider a giant omphalocele to be a protrusion with diameter > 10 cm (Ein and Langer, 2012). A small (minor) omphalocele may contain only part of the intestines, whereas a giant (major) omphalocele may also include all or parts of the liver, as well as portions of the small and large intestines (Mann, Blinman and Wilson, 2008). Up to 70% of the cases of omphalocele are accompanied by various other congenital abnormalities and defects (Mann, Blinman and Wilson, 2008).

Omphalocele is usually corrected surgically. Minor omphaloceles are typically corrected through primary closure in a single surgery. Various surgical approaches and techniques are applied in the cases of major omphaloceles either in a staged or delayed closure (van Eijck, 2011). Some methods use compression of the omphalocele for some period of time to force the protruding organs back into the abdominal cavity before closure is undertaken (DeLuca, Gilchrist and Paquette, 1996).

In certain cases for various reasons the omphalocele cannot be repaired, as is the case of the 8-year old patient with giant omphalocele presented in this study. The patient has undergone a series of, unfortunately, not very successful surgeries in an effort to return the organs (parts of the liver, the small intestines, and the large intestines) into the abdomen cavity. At present, the only strategy to address the problem, which is being exacerbated by natural organ growth and gravity, is to use a support garment that would help lock the position and restrict the movement of the omphalocele during daily body activities. Here we describe the development of a prototype for a medical support garment for this patient.

DESIGN PROBLEM STATEMENT

Currently, the patient’s omphalocele is approximately 16 cm in diameter, protruding about 15 cm from the abdomen, and has a base of about 12 cm in diameter. Supported only by skin, the omphalocele sags under its weight and, being a concentrated mass, moves relatively unrestricted. To restrict the movement of the omphalocele as well as to support it, a garment made for this patient would likely have features in common with designs of items such as brassieres, pregnancy girdles, and baby carriers. However, presenting a challenge for our design work and limiting the possibilities of direct borrowing of ideas from designs of girdles, bras, and alike, are the following important differences: Unlike the support provided by bras and baby carriers, the garment supporting the omphalocele must support a mass that is positioned much lower relative to the center of mass of the
body and is, thereby, changing the walking pattern of the patient drastically. Also, unlike in the case of pregnancy, the omphalocele is (a) not a protrusion that gradually builds up and away from the pubic bone/abdomen but it is rather abrupt and (b) it is not supported by abdominal muscles keeping it close to the body.

Furthermore, the omphalocele is soft and malleable and needs to be supported by a relatively stiff surface with large area. Other requirements for the garment design were set by the fact that the patient also uses a breathing tube (installed at front of the neck) and a feeding tube (attached above and the to left side of the omphalocele), access to which should not be obstructed. Also, since at this stage the patient is being dressed by a caregiver, the garment’s donning and doffing must be made easy for the caregiver. A list of the main criteria, which guided the design development of the support garment are presented in Table 1 (criteria are numbered for ease of reference only).

### Table 1. Criteria for garment design

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr-1</td>
<td>Patient uses a breathing tube</td>
</tr>
<tr>
<td>Cr-2</td>
<td>Patient uses a feeding tube</td>
</tr>
<tr>
<td>Cr-3</td>
<td>Patient needs assistance with dressing</td>
</tr>
<tr>
<td>Cr-4</td>
<td>Patient is able to walk</td>
</tr>
<tr>
<td>Cr-5</td>
<td>Omphalocele sags</td>
</tr>
<tr>
<td>Cr-6</td>
<td>Omphalocele is malleable</td>
</tr>
<tr>
<td>Cr-7</td>
<td>Omphalocele is heavy</td>
</tr>
<tr>
<td>Cr-8</td>
<td>Skin is sensitive</td>
</tr>
</tbody>
</table>

**SUPPORT GARMENT DEVELOPMENT**

The support garment was developed through a series of prototypes fitted to the patient, with adjustments made based on our fit evaluation and on input from patient and caregivers. The best method of developing garment patterns for such close-fitting (under)garment was to use draping techniques, where cloth is wrapped around the body, or better yet, around a mannequin, which has the shape of the body. Since the patient has a body shape quite different from the standard, a custom dress form was fabricated. The dress form replicated the shape and size of patient’s body exactly. It facilitated garment pattern development and allowed all initial fittings and adjustments of each prototype to be done on the dress form, without necessitating the presence of the patient.

**Custom Dress Form**

To develop the custom dress form, a three-dimensional (3D) body scan of the patient (see Figure 1) was taken using a VITUS XXL 3D full-body scanner by Human Solutions. The scan was manipulated digitally and cross sections of the scan were created along the longitudinal axis at every ¼ inch (see Figure 2). Slabs of ¼ inch thick Styrofoam® sheets were cut out in the shape of each of the body cross sections. All Styrofoam® cut-outs were appropriately aligned, stacked onto
wooden rods, and glued to each other, building a custom dress form (see Figure 3) in the shape of patient’s body.

Figure 2. Stacked cross sections of body scan.

Figure 3. Custom dress form of patient used for pattern development and initial fitting of prototypes.

Garment Design Features

Three fitting prototypes (without final finishes) were developed and eventually fitted in live fitting sessions with the patient, seeking input from the caregivers regarding fit, design, and use of materials. Several possible solutions were considered for each garment feature. Main design restrictions were due to the need for all-day support of the omphalocele and for patient comfort.

In the final garment the omphalocele was supported by a fabric pouch (see Figure 4) pulled up and toward the body by a system of elasticized straps wrapped around the torso (see Figure 5). The pouch was made of elastic materials in order to provide some pressure, forcing the organs into the abdominal cavity (Cr-5). The pouch was made in two separating layers, forming a pocket where an appropriately shaped removable soft plate (see Figure 6) was inserted. The plate was made of canvas stiffened with boning (boning, or bones, are long pieces of hard material installed strategically into garments such as corsets, strapless gowns, etc.,

Figure 4. Final garment. Front.
to prevent them from folding). We used special kind of metal spiral boning, which can bend in all directions, thus being very flexible. A mesh-like arrangement (see Figure 7) of the bones within the canvas plate provided continuous support of the omphalocele, while making the plate flexible in all directions and allowing it to fold like an accordion, if necessary. Ultimately, the pouch with the soft plate insert provided a shelf-like support for the omphalocele at all points of support (Cr-6), while allowing the patient to bend comfortably.

![Figure 5. Final garment. Back.](image)

The strap system that lifted the shelf-like pouch to the level of the abdominal cavity (Cr-5) had four types of pulling/anchoring mechanisms (see Figure 4 and Figure 5): (a) a wide shaped belt with Velcro® closure at center back, extending from center front under the omphalocele (center-front width of 1.5 inches, or 3.8 cm) to center back (center-back width of 4.5 inches, or 11.4 cm) and resting on the hips below the small of the back, anchored the garment vertically; (b) wide, shaped diagonal straps pulling the sides of the pouch down towards the back of the belt; (c) wide, shaped diagonal straps pulling the sides of the pouch up and around the torso under the arms connecting to the ends of (d) wide, shaped straps crossing in the back, turning around the shoulders, and attaching in front to the top of a wide ‘plate’ that rests on the chest and attaches to the top of the pouch, pulling it up and towards the body. All straps were made wide in order to distribute the pressure over a large area and provide comfort (Cr-7).

An elastic strap (using a buckle for adjustability) was looped under the pouch with the soft plate, i.e. under the omphalocele. Both ends of this elastic loop were attached to the bottom of the front chest plate, lifting the pouch with the omphalocele (Cr-5 & Cr-6) and bringing the center of gravity closer to its natural location on the body thereby improving patient’s balance and posture.
(Cr-4). A non-stretch strap (also with length adjustable by a buckle) was installed between the most protruding point of the pouch and the bottom of the chest plate. This strap provided additional point of lifting the omphalocele at center front.

Separating (in the back) shoulder straps were preferred over pull-over straps to avoid interference with the breathing tube (Cr-1) during donning and doffing. The garment closed in the back (using bra hooks), providing convenience to the caregiver (Cr-3), while preventing accidental removal of the garment by the patient. The pouch had a top opening, ensuring access to the feeding tube (Cr-2). The top opening also allowed for ventilation of the omphalocele.

The final prototype was a completely finished garment. Most of the edges were bound with soft tape in order to prevent the garment from rubbing the skin (Cr-8). The inside of the front chest plate was lined with soft material to cushion the pressure of the plate onto the body.

GARMENT TESTING

The final prototype was presented to the patient for wear testing (see Figure 8). Patient was able to tolerate the garment for full-day wear only after two days of incremental wear. Following wear testing feedback, few minor adjustments were introduced. The patient and the caregivers have expressed satisfaction with the final garment design.

REFERENCES