A 25-Year Experience with Hemicorporectomy for Terminal Pelvic Osteomyelitis

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Background: Hemicorporectomy involves amputation of the pelvis and lower extremities by disarticulation through the lumbar spine with concomitant transection of the aorta, inferior vena cava, and spinal cord. In addition, conduits are constructed for diversion of both the urinary and fecal streams. Of 57 cases reported in the literature, limited experience exists with hemicorporectomy for terminal pelvic osteomyelitis, with only 11 cases described. Furthermore, there is little information available regarding perioperative mortality and long-term survival. This article describes the largest reported series of hemicorporectomies performed for terminal pelvic osteomyelitis.
Methods: A retrospective review of the medical records for nine patients who underwent hemicorporectomy at the authors' institution was conducted followed by interviews with all surviving patients.
Results: At follow-up, four patients were alive and five patients were dead. For all patients, the average survival after hemicorporectomy was 11.0 years (range, 1.7 to 22.0 years). There was no perioperative mortality within 30 days of surgery. None of the surviving patients suffered from recurrent decubitus ulcers.
Conclusions: Including this clinical series, a total of 66 hemicorporectomies have now been reported in the literature. Twenty cases were performed for terminal pelvic osteomyelitis with no mortality within 30 days of surgery, and 53.3 percent of patients were alive and well at long-term follow-up. Given the low perioperative mortality along with the ability of patients to achieve long-term survival following this operation, hemicorporectomy should be offered to appropriate patients suffering from terminal pelvic osteomyelitis. (*Plast. Reconstr. Surg.* 124: 1165, 2009.)

Hemicorporectomy, or translumbar amputation, involves amputation of the pelvis and lower extremities by disarticulation through the lumbar spine with concomitant transection of the aorta, inferior vena cava, and spinal cord. In addition, conduits are constructed for diversion of both the urinary and the fecal streams. Originally proposed by Kredel[1] in 1950, the first successful hemicorporectomy was performed by Kennedy and colleagues[2] in 1960. Aust and Page[3] reported the first long-term survival following hemicorporectomy, with the patient surviving 18.8 years.

A comprehensive review of the world literature reveals that 57 cases[1–63] have been reported, although undoubtedly more have been performed (Table 1). Forty procedures were performed for malignant disease, 14 procedures were performed for benign disease, and three proce-

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Table 1. Literature Review of Hemicorporectomy Cases

Case	Reference	Indication	Type of Disease	Follow-Up	Cause of Death
1	Kennedy et al., 1960[2] Patel, 1960[4]	Recurrent rectal adenocarcinoma	Malignant	11 days	Pulmonary edema
2	Aust and Absolon, 1962[5]	SCC in decubitus ulcer	Malignant	18 yr 10 mo	Pulmonary edema
3	Aust and Page, 1985[3]	Recurrent SCC in burn scar of groin	Malignant	4 yr AAW	
4	Aust and Page, 1985[3]	Terminal pelvic osteomyelitis	Benign	4 yr AAW	
5	Aust and Page, 1985[3]	Terminal pelvic osteomyelitis	Benign	Unreported	
6	Aust and Page, 1985[3]	Terminal pelvic osteomyelitis	Benign	Unreported	
7	Aust and Page, 1985[3]	Terminal pelvic osteomyelitis	Benign	Unreported	
8	Yancey et al., 1964[6]	Recurrent cervical SCC	Malignant	4 days	Pulmonary edema
9	Miller et al., 1966[7] Frieden et al., 1969[9] Miller, 1982[11] Mackenzie, 1989[12] Mackenzie, 1995[13]	Bladder carcinoma	Malignant	28 yr 5 mo	Bowel obstruction
10	Miller et al., 1966[8] Miller, 1982[11]	Bladder carcinoma	Malignant	1 yr	Metastatic disease
11	Miller et al., 1966[14] Miller, 1982[11]	Vaginal carcinoma	Malignant	9 mo	Metastatic disease
12	Mackenzie et al., 1967[15] Miller, 1982[11]	Prostate leiomyosarcoma	Malignant	7 mo	Metastatic disease
13	Miller, 1982[11]	Anal SCC	Malignant	2 mo	Internal hydrocephalus
14	Miller, 1982[11]	Terminal pelvic osteomyelitis	Benign	12 yr AAW	
15	Miller, 1982[11]	Pelvic chondrosarcoma	Malignant	3 mo	Metastatic disease
16	Miller, 1982[11]	Osteogenic sarcoma	Malignant	1 yr 7 mo	Metastatic disease
17	Miller, 1982[11]	Terminal pelvic osteomyelitis	Benign	5 yr 8 mo	Cardiac arrest
18	Miller, 1982[11]	SCC in decubitus ulcer	Malignant	7 days	Renal failure from amyloidosis
19	Shafir et al., 1984[16]	Recurrent chondrosarcoma	Malignant	Unreported	
20	Garbay, 1967[17] Garbay and Alexandre, 1971[18]	Recurrent rectal adenocarcinoma	Malignant	6 days	Postoperative hemorrhage
21	Lamis et al. (Hawk), 1967[19]	Recurrent penile SCC	Malignant	1 mo 2 days	Hemorrhage from gastric ulcer
22	Lamis et al. (Hawk), 1967[19]	SCC	Malignant	4 days	Bronchopneumonia
23	Merle d'Aubigne et al., 1967[20] Saint Maurice et al., 1971[21]	Pelvic chondrosarcoma	Malignant	Unreported	
24	DeLateur et al., 1969[22]	SCC in decubitus ulcer	Malignant	Unreported	
25	DeLateur et al., 1969[22]	Colon adenocarcinoma	Malignant	Unreported	
26	Williams and Fish, 1969[23]	SCC in decubitus ulcer	Malignant	1 yr 2 mo AAW	
27	Minkari and Tanker, 1969[24]	Sacral chordoma	Malignant	20 days	Unreported
28	Schweisheimer, 1969[25] Schweisheimer, 1971[26] Simecek and Králik, 1973[27] Simecek and Králik, 1975[28]	Severe pelvic and lower extremity trauma	Trauma	1 day	Unreported
29	Baker et al., 1970[29]	Severe pelvic and lower extremity trauma	Trauma	Unreported	
30	Stener et al., 1971[30] Grimby et al., 1971[31] Grimby and Stener, 1973[32] Bake and Grimby, 1974[33] Stener, 1984[34] Stener, 1989[35]	Pelvic chondrosarcoma	Malignant	18 yr AAW	
31	Norris et al., 1973[37]	Colon adenocarcinoma	Malignant	5 mo	Metastatic disease
32	Davis et al., 1975[38]	Terminal pelvic osteomyelitis	Benign		5 yr AAW
33	Davis et al., 1975[38]	Terminal pelvic osteomyelitis	Benign		3 yr AAW
34	Pearlman et al., 1976[39]	SCC in decubitus ulcer	Malignant		Unreported

(*Continued*)

Table 1. (*Continued*)

Case	Reference	Indication	Type of Disease	Follow-Up	Cause of Death
35	Friedmann et al., 1981[40]	Recurrent perianal and scrotal fistulae	Benign		Unreported
36	Elliott and Alexander, 1992[41]	Pelvic fibrous histiocytoma	Malignant	15 days	Cardiac arrest during operation for small bowel obstruction
37	Woerth and Neal, 1988[42]	Pelvic chondrosarcoma	Malignant		1 yr 10 mo
38	Woerth and Neal, 1988[42]	Terminal pelvic osteomyelitis	Benign		Unreported
39	Fedorov et al., 1988[45] Smirnova et al., 1991[46] Smirnova, 1993[47] Fedorov et al., 2000[48]	Anal SCC	Malignant		12 yr AAW
40	Terz et al., 1990[49]	Pelvic chondrosarcoma	Malignant	2 yr	Metastatic disease
41	Terz et al., 1990[49]	Pelvic arteriovenous malformation	Benign	6 yr AAW	
42	Terz et al., 1990[49]	Sacral chondroma	Malignant	4 yr AAW	
43	Terz et al., 1990[49]	Sacral chondroma	Malignant	4 yr 8 mo AAW	
44	Terz et al., 1990[49]	SCC in decubitus ulcer	Malignant	6 mo	Metastatic disease
45	Terz et al., 1990[49]	Sacral giant cell tumor	Malignant	1 yr 6 mo AAW	
46	Raven and Brugger, 1992[50]	Recurrent giant cell tumor of back	Malignant	5 mo	Pulmonary embolus
47	Smith et al., 1992[51] Tuel et al., 1992[52]	Lumbar ependymoma			Malignant
48	Abrams et al., 1992[53]	Acute aortic occlusion	Benign	Unreported	
49	Sanford et al., 1993[54]	SCC in decubitus ulcer	Malignant	Unreported	
50	Stelly et al., 1995[55]	Terminal pelvic osteomyelitis	Benign	Unreported	
51	North et al., 1997[56]	SCC	Malignant	Unreported	
52	Porter-Romatowski and Deckert, 1998[5]	SCC in decubitus ulcer	Malignant	Unreported	
53	Richardson et al., 1999[58]	Severe pelvic and lower extremity trauma	Trauma	1 mo 14 days	Hemorrhage from bronchopulmonary artery fistula
54	Weaver and Flynn (Karakousis), 2000[59]	SCC in decubitus ulcer	Malignant	6 mo	Enteric fistula
55	Chang et al., 2000[60] Fourney et al., 2005[61]	SCC in pilonidal cyst	Malignant	6 yr AAW	
56	Shields and Dudley-Javoroski, 2003[62]	Terminal pelvic osteomyelitis	Benign	12 yr	
57	Peterson and Sardi, 2004[63]	SCC in decubitus ulcer	Malignant	7 yr AAW	

AAW, alive and well at follow-up; SCC, squamous cell carcinoma.

dures were performed after trauma. Of the 40 patients for which follow-up was reported, 20 percent (eight patients) died within 30 days of the operation and 65 percent (26 patients) were dead at follow-up, with an average survival of 2.9 years (Table 2).

Originally proposed for locally invasive cancers confined to the pelvis, hemicorporectomy has since been performed for severe trauma to the pelvis and lower extremities,[29,58] vascular malformations,[49] acute aortic occlusion,[53] recurrent perianal and scrotal fistulas,[40] and terminal pelvic osteomyelitis.[3,11,38,42,55,62]

Terminal pelvic osteomyelitis is defined as a spectrum of disease caused by pelvic osteomyelitis associated with chronic decubitus ulcers that are refractory to antibiotics and standard surgical treatments. At one end of the spectrum, patients

Table 2. Summary of Survival following Hemicorporectomy Cases Reported in the Literature

	No. of Cases (%)
All indications	
Mortality within 30 days or less	8 (14.0)
Mortality after 30 days	18 (31.6)
Alive and well	14 (24.6)
Unreported survival	17 (29.8)
Malignant disease	
Mortality within 30 days or less	7 (17.5)
Mortality after 30 days	15 (37.5)
Alive and well	9 (22.5)
Unreported survival	9 (22.5)
Terminal pelvic osteomyelitis	
Mortality within 30 days or less	0 (0.0)
Mortality after 30 days	2 (18.2)
Alive and well	4 (36.4)
Unreported survival	5 (45.4)

require wound care and frequent and often extended hospital admissions for complications that significantly impair their quality of life. At the other end of the spectrum, patients develop systemic consequences, including life-threatening sepsis and death.

Limited experience exists with hemicorporectomy for terminal pelvic osteomyelitis, with only 11 cases previously described in the literature. Furthermore, little information is available regarding perioperative mortality and long-term survival. In this article, we describe the largest reported series of hemicorporectomies performed for terminal pelvic osteomyelitis, which almost doubles the existing world literature on this topic. In addition, indications for hemicorporectomy, perioperative considerations, evolution of the technique, rehabilitation, and perioperative mortality and long-term prognosis after hemicorporectomy are discussed.

PATIENTS AND METHODS

A retrospective review of the medical records for all nine patients who underwent hemicorporectomy at the University of Texas Southwestern Medical Center at Dallas was conducted followed by interviews with all four surviving patients in June of 2007.

RESULTS

Between November 30, 1981, and October 25, 2005, one woman and eight men underwent hemicorporectomy for terminal pelvic osteomyelitis (Table 3). All patients had been paraplegics for an average of 10 years (range, 2 to 23 years) before hemicorporectomy. All patients had undergone multiple surgical procedures including wound débridements and local flaps in an attempt to treat their chronic decubitus ulcers. In addition, two patients had undergone unilateral hip disarticulation, one patient had undergone bilateral hip disarticulation, one patient had undergone hemipelvectomy, and one patient had undergone both hemipelvectomy and hemisacrectomy. At the time that hemicorporectomy was considered, one patient had an ileostomy, four patients had colostomies, and three patients had undergone procedures for urinary diversion.

The average age at surgery was 36.3 years (range, 21.3 to 46.3 years). Two cases were performed in a single stage and the other seven cases were staged. The average duration of surgery for the stage entailing actual hemicorporectomy was 8.5 hours (range, 6.9 to 12.3 hours). The average estimated blood loss was 5.9 liters (range, 0.7 to 12.0 liters). The average length of hospital stay following hemicorporectomy was 119 days (range, 48 to 203 days).

At follow-up, four patients were alive and five patients were dead. For surviving patients, the average age at follow-up was 47.6 years (range, 46.8 to 49.0 years) and the average survival since surgery was 12.0 years (range, 1.7 to 22.0 years). None of these patients suffered from recurrent decubitus ulcers. For patients who died, the average age at death was 48.1 years (range, 30.2 to 60.0 years) and the average survival after surgery was 10.3 years (range, 7.5 to 18.7 years). The cause of death was urosepsis for one patient, a fall for one patient, portal vein thrombosis for one patient, and unknown cause for two patients. For all patients, the average survival after hemicorporectomy was 11.0 years (range, 1.7 to 22.0 years).

Complications

In this clinical series, there was no intraoperative or 30-day postoperative mortality. Surgery was complicated by intraoperative hypotension that responded to resuscitation with intravenous fluids and blood products in two cases. Postoper-

Table 3. Data for the Patients Who Underwent Hemicorporectomy for Terminal Pelvic Osteomyelitis

Patient	Time between Onset of Paraplegia and Hemicorporectomy (yr)	Sex	Age at Surgery (yr)	Date of Surgery	Duration of Surgery (hr)	Length of Postoperative Admission (days)	Age at Death (yr)	Age at Follow-Up (yr)	Length of Survival at Follow-Up (yr)
1	2	F	21.3	11/30/1981	7.8	127	30.2	N/A	8.8
2	10	M	38.6	08/19/1983	8.1	159	49.4	N/A	10.8
3	12	M	46.3	11/23/1984	10.0	182	53.8	N/A	7.5
4	4	M	23.8	06/13/1985	7.4	91	N/A	46.8	22.0
5	6	M	26.3	10/02/1985	7.0	203	N/A	49.0	21.7
6	15	M	41.4	06/04/1986	6.9	126	47.1	N/A	5.7
7	6	M	41.3	08/20/1986	7.4	77	60.0	N/A	18.7
8	19	M	44.9	12/03/2004	9.3	48	N/A	47.5	2.5
9	23	M	43.3	10/25/2005	12.3	54	N/A	47.0	1.7

F, female; M, male; N/A, not applicable.

atively, all patients experienced wound complications, including superficial wound dehiscence, delayed wound healing, and osteomyelitis of the distal lumbar spine. Seven of these patients required additional surgical procedures, including wound débridements and local flaps. Despite these early wound complications, all patients alive at follow-up experienced complete resolution of their wounds (Figs. 1 through 3). Genitourinary complications including recurrent urinary tract infections, pyelonephritis, renal calculi, and urosepsis were experienced by six patients. Two patients suffered from early postoperative depression and one patient with a preoperative history of chronic pain developed chronic phantom pain postoperatively.

Patient 1 in our series developed cerebral empyema resulting in mental retardation and seizure disorder secondary to a postoperative superficial wound dehiscence over the inferior lumbar vertebrae. Although this wound ultimately healed following multiple débridements,

Fig. 1. (*Left* and *center*) Photographs of patient 4 obtained at 22-year follow-up. Along with the other patients in this series, he no longer suffered from decubitus ulcers at long-term follow-up. (*Right*) Photograph of the patient with his 7-year-old daughter. She was conceived by artificial insemination after the patient had his sperm banked before hemicorporectomy.

Fig. 2. (*Left* and *center*) Photographs of patient 5 obtained at 21.7-year follow-up. (*Right*) Along with other surviving patients, he uses a wheelchair with a ROHO cushion instead of a bucket prosthesis, which he abandoned after it caused persistent skin breakdown.

Fig. 3. (*Left* and *center*) Photographs of patient 9 obtained at 1.7-year follow-up. (*Right*) These patients are able to live independently, lead active social lives, and even drive cars.

the patient was left with permanent neurologic disability.

The postoperative course of patient 6 in our series was complicated by postoperative hemorrhage from the lower abdominal incision that required emergent reoperation. This patient went on to develop both a parastomal hernia and an enterocutaneous fistula requiring multiple operations to resolve. The postoperative course of patient 9 was complicated by the development of a chyle leak that resolved with bowel rest and a 10-day course of total parenteral nutrition.

DISCUSSION

Indications for Hemicorporectomy

Although originally proposed for the treatment of locally invasive cancers confined to the pelvis, the role of hemicorporectomy has been relegated to a last resort in the treatment of malignant disease because of the dramatic improvement in nonsurgical treatment modalities for cancer, including chemotherapy and radiation therapy. Recently, hemicorporectomy has been more commonly performed for terminal pelvic osteomyelitis. We have found that hemicorporectomy represents a definitive treatment in appropriate circumstances that provides resolution of chronic decubitus ulcers that are refractory to less invasive treatments and routine reconstructive surgery. More importantly, postoperative hemicorporectomy patients in this series did not require the time-consuming dressing changes and recurrent and prolonged hospital admissions as they did preoperatively. At follow-up, all patients reported that they were extremely satisfied that they underwent hemicorporectomy.

In this series, patients presented for evaluation for hemicorporectomy after other less aggressive treatment options had failed. All patients had undergone multiple surgical procedures in an attempt to treat their chronic decubitus ulcers. Some patients had undergone urinary and fecal diversion. All patients had experienced sepsis secondary to terminal pelvic osteomyelitis and had received multiple courses of both oral and intravenous antibiotics. By the time these patients presented for their initial evaluation at our medical center, they were all malnourished, and some were even acutely septic and responding poorly to chronic suppressive antibiotic therapy. We feel that earlier consideration for hemicorporectomy is warranted for patients with proven diffuse pelvic osteomyelitis who have received multiple antibiotic courses without resolution of their pelvic osteomyelitis. From a technical standpoint, both the multiple operations that these patients have undergone and the chronic and recurrent bouts of pelvic sepsis led to an operative dissection that was more difficult to perform because of local inflammation and scarring. In addition, it has been very difficult to achieve optimal preoperative nutritional status in patients with terminal pelvic osteomyelitis despite aggressive nutritional supplementation and management by our nutritionists, most likely secondary to chronically exudative wounds and a highly catabolic state resulting from chronic inflammation and infection. Earlier con-

sideration for hemicorporectomy may allow for better preoperative optimization and a less technically challenging operation, thus leading to better outcomes.

In evaluating which patients will benefit from hemicorporectomy for terminal pelvic osteomyelitis, we have modified criteria previously outlined by Terz and colleagues[49]: (1) a diagnosis confirmed by clinical history and appropriate imaging (i.e., computed tomography or magnetic resonance imaging) revealing diffuse pelvic osteomyelitis and biopsy-proven osteomyelitis; (2) normal life expectancy after hemicorporectomy and achievement of a quality of life that would be expected for someone of equal disability without terminal pelvic osteomyelitis; and (3) the emotional and psychological capacity to understand and cope with the extensive physical, functional, and emotional disability resulting from the loss of the lower half of the body.

Perioperative Considerations

To achieve successful outcomes with low morbidity and mortality, it is essential to use a multidisciplinary approach to care for the patient undergoing hemicorporectomy. This involves the coordination of multiple surgical services, including general surgery, plastic surgery, neurosurgery, and urology. In addition, anesthesiology, psychiatry, physical medicine and rehabilitation, nutrition, enterostomal therapy and wound care nursing, and infectious disease specialists provide the full complement of expertise required to care for these complex patients.

Although all of the specific details pertaining to the perioperative management of the hemicorporectomy patient are beyond the scope of this article, some of the more important perioperative considerations include awareness of postoperative changes in fluid and acid-base balance, cardiovascular function, and respiratory function.[19,32,33,59]

Postoperative mortality in early reports of hemicorporectomy was largely attributable to pulmonary edema from volume overload. After hemicorporectomy, the body mass is decreased by 33 to 55 percent[19,59] and the circulating blood volume is reduced to a lesser extent. Loss of muscle mass is thought to affect fluid, acid-base, and electrolyte balance[19] and makes these patients susceptible to volume overload and pulmonary edema in the perioperative period. In addition, most paraplegics have a lower baseline mean arterial pressure, and this should not be mistaken for volume underresuscitation in the perioperative period. In addition to loss of muscle mass, loss of body surface area affects heat dissipation and temperature regulation,[59] causing these patients to have decreased ability to regulate body temperature, especially during exercise.[19,32]

During hemicorporectomy, ligation of the common iliac and distal superficial femoral vessels causes an acute increase in systemic vascular resistance and cardiac afterload, which may precipitate cardiac failure and pulmonary edema in susceptible patients. Preoperative cardiovascular evaluation is challenging in paraplegics because it is difficult to assess their functional capacity by history and physical examination alone. Echocardiography and noninvasive stress testing are particularly useful for predicting perioperative cardiac events in patients who are unable to exercise and should be performed in paraplegics with clinical risk factors.[64]

Total lung capacity, vital capacity, and functional residual capacity decrease by 37, 40, and 52 percent, respectively, following this procedure, and regional changes in ventilation occur with decreases in the basal lung zones.[32,33] There is further reduction of functional residual capacity in the supine position. These changes are likely attributable to reduced abdominal compliance and underscore the importance of preoperative pulmonary optimization, including smoking cessation and aggressive pulmonary toilet in the postoperative period. Preoperative pulmonary function tests are strongly advocated. Finally, meticulous wound care and pressure sore prevention, extensive rehabilitation,[9,22,36,38,40,51,52,57,62] and psychological and emotional support are critical in the postoperative period.

Evolution of the Operative Technique

The first hemicorporectomy in this series was performed in a single stage using the standard anterior-to-posterior approach.[5,11] Direct closure of the lower abdominal wound was performed in a fishmouth fashion, under undue tension. Undoubtedly, early breakdown of this incision allowed exposure of the spinal canal, causing meningitis and a cerebral empyema resulting in mental retardation. During the second case in August of 1983, a musculocutaneous subtotal thigh flap based on the superficial femoral vessels[60,65] was used to provide a tension-free closure and ample cushioning for the amputated lumbar spine. Since then, this method of closure has been used in all cases (**see Videos, Supplemental Digital Content 1, 2, and 3**, ***http://links.lww.com/PRS/A92***, ***http://links.lww.com/PRS/A93***, and ***http://links.lww.com/PRS/A94*** respectively).

Supplemental Digital Content 1, 2, and 3. Supplemental Digital Content 1 demonstrates how the subtotal thigh flap is dissected and elevated, ***http://links.lww.com/PRS/A92***. Supplemental Digital Content 2 demonstrates removal of the amputated lower body, ***http://links.lww.com/PRS/A93***. Supplemental Digital Content 3 demonstrates that the subtotal flap is easily rotated to cover the lower abdominal defect, ***http://links.lww.com/PRS/A94***.

Fig. 4. Deep partial-thickness skin grafts have been harvested from the right thigh of the amputated lower body and are stored with transplant services.

Although wound complications remain high following the use of this flap, serious sequelae, as described above caused by exposure of the lumbar vertebrae, have been avoided. In addition, given the 100 percent incidence of wound complications, we now harvest deep partial-thickness skin grafts from the amputated lower body and store them with transplant services in case they are needed in the future (Fig. 4). These skin grafts undergo processing with a cryoprotectant and control-rate freezing and are stored at −130°C for up to 5 years.

After the eighth hemicorporectomy in this series, a review of our institutional experience revealed the following: blood losses of up to 12 liters, morbidity of 100 percent, and durations as long as 7 months in the hospital for recovery and rehabilitation.[65] After ligation of the inferior vena cava during the standard anterior-to-posterior approach, the Batson plexus becomes engorged, leading to marked blood loss during division of the vertebral structures and spinal cord. In October of 2005, the case 9 was performed "back to front" (Figs. 5 and 6).[65] This approach involves early division of the vertebral structures and spinal cord, preempting engorgement of the Batson plexus, thus minimizing blood loss and neurogenic hypotension. In addition, the back-to-front approach with the patient in the lateral decubitus position greatly improved exposure of the pelvic vessels, allowing for a technically less challenging and safer procedure.[65] With the back-to-front approach, estimated blood loss was decreased from an average of 6.9 liters to only 700 ml and the postoperative hospital stay was decreased from an average of 127 days to 54 days.[65]

Currently, if a patient has not undergone diversion of both the urinary and the fecal streams, we prefer to perform hemicorporectomy in two stages, with an ileal conduit urostomy and colostomy performed during the first stage and actual hemicorporectomy performed at the second stage. We allow a minimum of 10 days for the patient to convalesce after the first stage, including a return of bowel function, before performing the second stage. The major stages of the operative sequence for two-stage hemicorporectomy are outlined in Table 4.

Rehabilitation after Hemicorporectomy

Rehabilitation after hemicorporectomy involves physical and occupational therapy and psychological counseling and support. In addition, vocational training may be necessary for the hemicorporectomy patient wishing to obtain gainful employment.

All patients participate in physical and occupational therapy following hemicorporectomy that entails upper body strength conditioning, transfers and mobility training, and acquisition of wheelchair skills. Patients spend 4 weeks in a Cli-

Fig. 5. (*Above*) The level of amputation and a subtotal thigh flap are marked. (*Below*, *left*) The incision is extended across the L4–5 level posteriorly, around the right flank, and then angled down along the anterior pelvic brim. (*Below*, *right*) After transection of the Batson plexus using bipolar electrocautery, intradural 1% lidocaine is administered to prevent spinal shock and the nerve roots are transected using bipolar electrocautery.

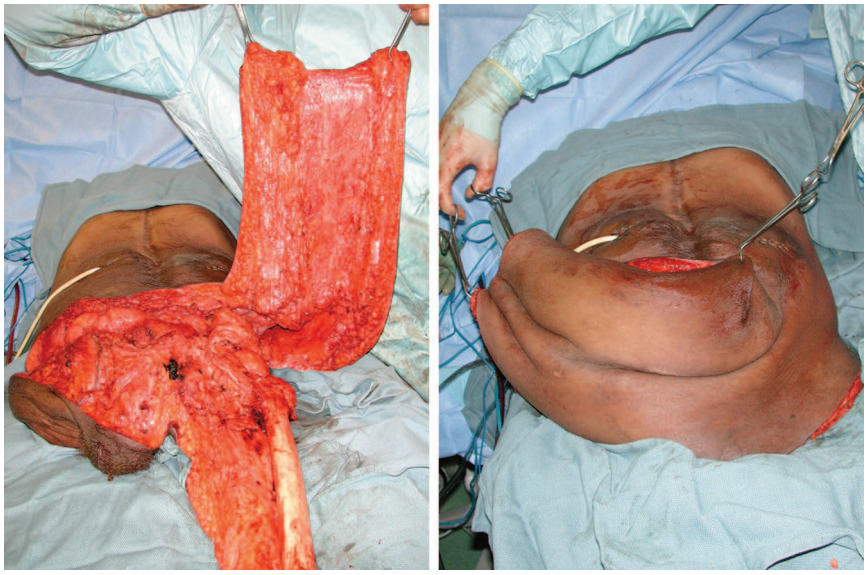

Fig. 6. (*Left*) A robust subtotal thigh flap is shown after dissection. (*Right*) The flap is easily rotated into position to close the lower abdominal wound without tension.

Table 4. Operative Sequence for Two-Stage Hemicorporectomy

	Department
First stage	
Ileal conduit urostomy	Urology
Colostomy	General surgery
Second stage	
Operative exposure	General surgery and plastic surgery
Disarticulation of the lumbar spine and transection of the spinal cord	Neurosurgery
Extraperitoneal dissection and ligation of the common iliac artery and vein	General surgery
Dissection of the subtotal thigh flap and closure	Plastic surgery

nitron II air fluidized therapy bed (Hill-Rom, Batesville, Ind.) in the immediate postoperative period to allow the subtotal thigh flap to heal. After this period, patients begin to spend progressively longer periods of time weight bearing on their lower torso until they are able to tolerate weight bearing for up to 2 hours at a time. Next, they are taught transfers and mobility training. Given that all nine patients were paraplegics before hemicorporectomy, most were able to return to their normal activities of daily living, both recreational and professional, after completing rehabilitation. In fact, most patients felt that they had improved mobility following removal of their nonfunctional lower extremities. Patients reported that this improved mobility made it easier to perform pressure-relieving maneuvers, and we believe that this likely contributes to preventing the development of decubitus ulcers despite the subtotal thigh flap being insensate.

Physical therapy is also responsible for fitting of a prosthesis and wheelchair modifications to meet the specific needs of these patients. Various authors[3,22,40,44,57,59,62,63] have reported on the utility of a bucket prosthesis, which is made of fiberglass shaped from a plaster mold of the patient's lower torso. It is approximately 1.5 cm thick and has holes for the urostomy and colostomy apparatuses. A bucket prosthesis was fabricated for each of the first seven patients in our series. The last two patients declined to have a bucket prosthesis fit for them. Instead, they elected to use a wheelchair with a ROHO cushion (The ROHO Group, Belleville, Ill.). At follow-up, all four surviving patients were using a wheelchair with a ROHO cushion. The two longest survivors in this series reported that they actually experienced wound breakdown secondary to the bucket prosthesis, citing pressure and heat blisters as the inciting factors. After abandoning the bucket prosthesis, both of these patients reported resolution of their wounds.

Psychological counseling and support is offered to all patients both preoperatively and postoperatively. Preoperatively, patients are seen by a psychiatrist to evaluate their capacity to understand the procedure and the extensive physical, functional, and emotional disability resulting from it. Families of the patients are also invited to attend these meetings so that they, too, will understand the extent of the procedure and the resulting physical changes. Postoperatively, a psychiatrist reevaluates patients and are available for any emotional issues that may arise such as depression or problems with adjustment to the change in body image. Interestingly, at follow-up, body image was of little concern to these patients. Instead, patients reported that they were grateful to have undergone this procedure.

Only one patient went on to pursue further vocational training following hemicorporectomy (attending community college). Of the nine patients, one patient went on to procure gainful employment (owning a carpentry company). However, it appears that the lack of gainful employment obtained by this patient group is related less to their disability and more to the difficulty in securing disability and health insurance if gainfully employed. Three other patients went on to participate in volunteer work.

Perioperative Mortality and Long-Term Prognosis after Hemicorporectomy

Including this series, mortality within 30 days of surgery was 16.3 percent when hemicorporectomy was performed for any indication. At follow-up, 36.7 percent of patients were alive and well when hemicorporectomy was performed for any indication. However, when performed for terminal pelvic osteomyelitis, there was no perioperative mortality reported within 30 days of surgery, and 53.3 percent of patients were alive and well at an average follow-up of 9.4 years. This is markedly better than when hemicorporectomy is performed for malignant disease, with only 29.0 percent of patients alive at an average follow-up of 3.7 years.

At the time of this clinical review of nine patients, the average survival after hemicorporectomy was 11.0 years. The earliest death occurred 7.5 years after hemicorporectomy. Although it is difficult to predict what the life expectancy of these patients would be had they

not undergone this procedure, given that all of these patients had experienced sepsis secondary to terminal pelvic osteomyelitis and that they received multiple antibiotic courses and had undergone less invasive surgical treatments without resolution of their wounds, it would be reasonable to state that hemicorporectomy likely led to an increase in life expectancy. More importantly, all surviving patients reported that they were satisfied with their decision to undergo hemicorporectomy.

Limited information exists in the literature regarding long-term survival after hemicorporectomy. Mackenzie[13] reports the longest survivor, who survived for 28 years 5 months after hemicorporectomy for bladder carcinoma. When performed for terminal pelvic osteomyelitis, Miller[11] reports the longest survivor, who at 12 years postoperatively was alive and well. In this series, we present two patients who are alive and well more than 21 years after hemicorporectomy.

CONCLUSIONS

A retrospective review of nine patients who underwent hemicorporectomy between 1981 and 2005 was performed. At follow-up, four patients were alive and well and five patients were dead. The average survival after hemicorporectomy was 11.0 years at follow-up. All four patients interviewed reported that they were happy to have undergone the procedure, which not only extended their lives but also led to resolution of their chronic decubitus ulcers.

This clinical series of nine patients almost doubles the existing world literature on hemicorporectomy performed for terminal pelvic osteomyelitis. Including this clinical series, a total of 66 hemicorporectomies have now been reported in the literature. Twenty cases were performed for terminal pelvic osteomyelitis, with no perioperative mortality within 30 days of surgery, and 53.3 percent of patients were alive and well at long-term follow-up. In conclusion, given the low perioperative mortality along with the ability of patients to achieve long-term survival following surgery, hemicorporectomy should be offered to patients suffering from terminal pelvic osteomyelitis, when appropriate.

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