

Rehabilitation after Hemipelvectomy

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Abstract: This article presents two clinical cases of women ages 34 and 76, both of whom required internal hemipelvectomy to resect malignant bone tumors. Their clinical courses were radically different representing the extremes of uncomplicated and complicated clinical courses in patients undergoing major pelvic resections. These cases illustrate relevant and important issues that must be considered during rehabilitation, specifically, deconditioning, pain control, altered gait mechanics, altered sexual functioning, and edema/lymphedema management. Collaboration between orthopaedic surgery and rehabilitation medicine is essential to the successful treatment of these patients.

Introduction

Rehabilitation after internal hemipelvectomy for resection of malignant bone tumors represents an increasingly common and necessary opportunity for clinical collaboration between orthopaedic surgery and rehabilitation medicine. These patients present a particularly challenging array of clinical issues including deconditioning, pain management, altered gait mechanics, altered sexual functioning, and edema/lymphedema management. A MEDLINE search revealed no citations on this topic. A survey of the major rehabilitation medicine journals revealed no isolated case studies. Thus, it becomes essential to report case studies as is done here, as an initial step in expanding our collaborative clinical knowledge base in the area of orthopaedic cancer rehabilitation.

Case Study #1

SS is a 34-year-old healthy female who had a left internal hemipelvectomy to resect a left acetabular chondrosarcoma. She experienced left hip pain during ambulation for approximately one year prior to the surgical procedure. Three months prior to surgery, diagnostic investigation with magnetic resonance imaging (MRI) revealed a left pelvic mass. Multi-organ investigation, including mammography and chest radiography, was unrevealing for metastases, and a diagnostic biopsy confirmed a chondrosarcoma. During the two months prior to surgery, ambulation became progressively painful and severely limited (Fig. 1).

The surgical resection encompassed resection of the left sacroiliac joint and the left innominate bone including the pubis, acetabulum, and ischium. The final pathology was Grade 2 chondrosarcoma with clean bone and soft tissue margins. Intraoperatively, SS required transfusion with two units of packed red blood cells to compensate for blood loss. Postoperatively, she required transfusion with another four units of red blood cells, however the post-surgical course otherwise was uncomplicated. Immediate post-surgical pain was controlled with epidural narcotic analgesia. Oral narcotic analgesia was initiated on the fourth post-surgical day. Thromboembolic prophylaxis with coumadin was initiated with the goal to maintain the international normalized ratio (INR) between 1.3 and 1.5. Rehabilitation medicine consultation occurred on the third post-surgical day, at which point the neuromuscular exam demonstrated no unusual sensory or motor deficits. SS was cleared to be out of bed into a bedside reclining chair on the fifth post-surgical day, and moved from a critical care unit to a general orthopaedic surgery unit on the sixth post-surgical day. Initial physical therapy contact occurred on the eighth post-surgical day with SS being cleared for ambulation, non-weight-bearing on the left lower limb: SS required 50% assistance for out of bed transfers and 25% assistance to ambulate with a walker for five feet. She was admitted to the inpatient rehabilitation program on the tenth post-surgical day where her stay was uneventful. Antibiotics were started postoperatively for infectious prophylaxis of the wound, and these were continued until the wound stopped draining serosanguinous fluid on the tenth rehabilitation (twentieth post-surgical) day. She progressed to toe touch weightbearing at this point, and incrementally progressed in her basic mobility skills to the level of independence in all transfers and in ambulation with axillary crutches, with adequate gait velocity, for 150 feet on level surfaces, and on one flight of stairs. This occurred during a seventeen-day inpatient rehabilitation stay.

A psychiatry consultant followed the patient from the end of the stay in the critical care unit through discharge from rehabilitation for an appropriate emotional adjustment reaction and for advice about medications to regulate the sleep-wake cycles. Pain was adequately controlled during the rehabilitation stay using oral oxycodone, particularly with pre-medication before the therapy sessions. Ambulation trials and therapies initially were problematic because of poor voluntary motor control when attempting to elevate and advance proximal muscles in the left leg during the swing phase of gait, and because of expected post-surgical length-

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Fig. 1. Case Study #1: presurgical (Figure 1A) and postsurgical (Figure 1B) magnetic resonance imaging. Figure 1A (top) shows a solitary chondrosarcoma of the left acetabulum with internal lobulations, measuring $4.5 \times 3.7 \times 3.8$ cm and extending to involve the entire left acetabulum in its anterior and posterior dimensions. Figure 1B (bottom) reveals that the patient is status post removal of the left hemipelvis and left proximal femoral head and neck.

ening of the limb by two inches. A one and three-quarter inch lift initially was placed externally on the shoe of the right foot to facilitate a gravity controlled swing on the left, and until the left limb proximal muscles could be strengthened to initiate swing despite a lack of “bony anchor.” With progressive ambulation, left lower limb swelling increased, however, venous doppler studies were negative. Thigh-high support stockings adequately controlled lower limb edema. On the sixteenth rehabilitation day, the surgical staples were removed.

Durable medical equipment requirements to support safe and independent life at home included the rental of a manual wheelchair for long distance community ambulation. Because her sitting tolerance in 90° of hip flexion was only ten minutes at the time of discharge, a high reclining back and a foam-gel combination cushion were ordered to acces-

sorize this wheelchair. The patient also required a bedside commode for overnight toileting and a shower chair for safe bathing. Her health insurance policy did not cover home services, thus outpatient physical therapy was prescribed three times weekly to continue aggressive strengthening, reconditioning, gait, and balance training with unilateral assistive devices.

Six weeks after discharge from rehabilitation, the patient no longer required a wheelchair for long distance community ambulation. She was ambulating with crutches in the community and used a quad cane for household ambulation. With further healing of the surgical site concomitantly with more ambulation, the initially longer left leg progressively became two inches shorter than the intact right leg, requiring a compensatory external lift on the right shoe. She was able to drive an automatic car but not a small pick-up truck with a standard transmission, and started a sedentary part-time summer job at 20 hours weekly. This allowed continuation of outpatient physical therapy and a self-directed exercise program at a local fitness center. Thirteen weeks after surgery, she resumed full-time doctoral level professional training. She missed no school whatsoever given the timing of surgery, rehabilitation, and recovery during the summer vacation period. To support prolonged sitting in lectures at school and while studying, a ROHO cushion was prescribed to be used in a variety of seating situations. An ergonomically individualized orthotic desk chair also was prescribed. Physical therapy progressed to the point that she was cleared to participate in conservative equestrian activities as the patient was an expert horseback rider prior to surgery. She is currently able to canter on horseback without restrictions.

The patient was cleared to participate in all sexual activities with her long-term partner, despite initial hesitance. Subsequently, a physical therapist with expertise in pelvic floor function provided practical biomechanical advice for re-engaging in sexual intercourse and other sexual activities. She is now fully active sexually noting only minor discomfort during specific sexual positions. She continues to be followed every three months by rehabilitation medicine collaboratively with orthopaedic surgery. Future issues to be considered are an appropriate choice of moderately sedentary employment given realistic post-surgical changes in activity tolerance, and the use of a hip stabilizing orthosis for more physically demanding work and for horseback riding.

Case Study #2

RC was a 76-year-old woman who had a right internal hemipelvectomy to resect an extensive osteosarcoma. Her past medical history was remarkable for a carcinoma of the cervix 25 years prior which had been treated with hysterectomy and external beam radiation. Complications of the radiation treatment included radiation colitis which resulted in a partial small bowel resection ten years prior to the hemipelvectomy. Following the bowel resection, the patient reported chronic diarrhea usually controlled on low dose

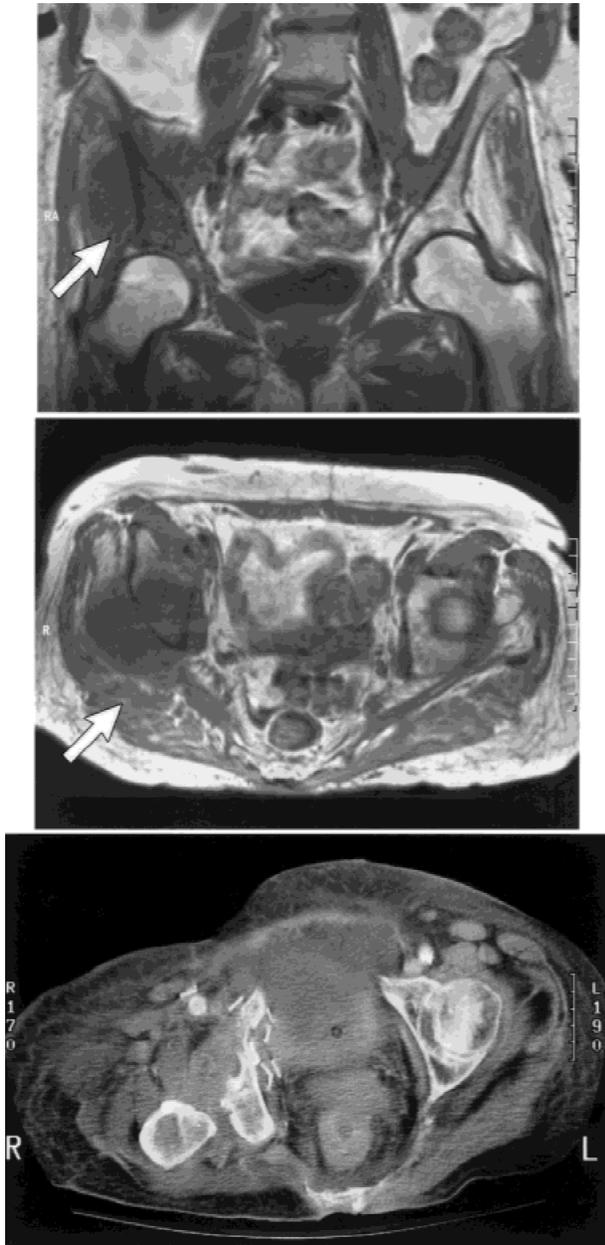


Fig. 2. Case Study #2: presurgical magnetic resonance imaging (Figure 2A and 2B) and postsurgical computerized tomography (Figure 2C). Figures 2A (top) and 2B (middle) show a sarcoma arising from the right innominate bone with a soft tissue mass that displaces the gluteus muscles. Figure 2C (bottom) demonstrates evidence of a right hemipelvectomy with extensive edema throughout the soft tissues.

immodium. She was also hypertensive, and had been a cigarette smoker but quit smoking ten years prior to the hemipelvectomy. She experienced rectal bleeding several months prior to the hemipelvectomy at which time an MRI of the abdomen and pelvis revealed a right pelvic mass. Subsequent diagnostic biopsy revealed an osteosarcoma. RC was given, a three-month course of adriamycin five months before surgery, resulting in less pain and more discrete definition of the tumor. Metastatic investigation was unremarkable (Fig. 2).

The patient was a highly independent, employed widow

who lived alone prior to surgery. A right internal hemipelvectomy was performed with radical resection of the right innominate bone. Complete tumor resection necessitated the sacrifice of the right gluteal vessels at the sciatic notch and several branches of the right sciatic nerve. Eight units of packed red blood cells were given perioperatively. Surgical pathology noted tumor free margins in bone and soft tissues.

Postoperatively, she was transferred to a critical care unit where she stayed for one week. The right lower limb initially was placed in a semi-rigid knee immobilizer, and a custom-molded orthoplast ankle foot orthosis was provided to maintain a fully extended knee and neutral ankle position, respectively. Postoperative pain initially was controlled with epidural narcotic analgesia. Initial rehabilitation medicine consultation occurred on the first postoperative day, revealing a cognitively intact patient whose lower limb exam was confounded by epidural anesthesia. On the second postoperative day a thrombocytopenia to 74,000 was observed, presumably because of heparin-induced exposure, which occurred during flushing of intravenous lines. Epidural narcotic anesthesia was replaced with peripheral intravenous patient-controlled narcotic analgesics on the third post-surgical day. She was weaned from supplemental nasal oxygen during the initial four post-surgical days, and the surgical wounds had decreasing serosanguinous drainage each day allowing the two drains to be removed on the sixth post-surgical day. She required transfusion of two more units of packed red blood cells on the fifth post-surgical day for a gradual drop in hemoglobin below 9. On the sixth post-surgical day, the posterior aspect of the surgical wound demonstrated a small necrotic area that was closely monitored by the orthopaedic and plastic surgical services.

After stopping epidural narcotic analgesia, gentle tactile stimulation of the distal right lower limb induced neuropathic hypersensitivity. Subsequently, low dose amitriptyline was initiated. Immodium continued to keep diarrhea under control during oral dietary advancement while in the critical care unit.

At the time that she was moved to the general orthopaedic surgical unit, she was cleared to be out of bed, and physical therapy was consulted on the seventh post-surgical day. During the initial physical therapy sessions, she required 50 to 75% assistance of two people to transfer out of bed into a bedside chair, to move from the sitting to the standing position, and to maintain standing with a walker, non-weight-bearing on the right lower limb. She was transferred to the inpatient rehabilitation unit on the tenth post-surgical day.

At this point, neuropathic pain, particularly with gentle tactile stimulation of the right lower limb, was poorly controlled. The orthoplast ankle foot orthosis was replaced with a more protective plastic orthosis to be used as a night time splint as well as during initial weight bearing attempts as she was quickly allowed to pursue weight bearing as tolerated. Intravenous narcotic analgesics were replaced with oral agents, specifically long acting morphine sulfate 30 mg every twelve hours as a standing dose, and intermediate release morphine sulfate 15 mg every four hours as a "res-

cue" agent for breakthrough pain. Amitriptyline 25 mg at bedtime was continued, and gabapentin 100 mg at bedtime was started, and gradually increased to a dose of 100 mg three times daily over one week. This combination of analgesic medications adequately controlled wound and right leg neuropathic pain, and facilitated regulation of sleep-wake cycles within a 48-hour period.

Elementary neurological examination of the right lower limb at the time of inpatient rehabilitation admission revealed 0/5 dorsiflexor, 3/5 plantar flexor, 1/5 hip flexor, knee extensor, hip abductor, and abductor in the supine position. During the initial week of inpatient rehabilitation, she progressed functionally but required 25 to 50% assistance of two people to get into and out of bed, 25% assistance of two people to stand up, and 50% assistance of two people to ambulate with a walker for five feet. Out-of-bed sitting tolerance was four hours. One week after starting inpatient rehabilitation, she was taken back to the operating room by plastic surgery for aggressive treatment of post-operative wound necrosis. A primary surgical revision of the original right gluteal flap was performed. The patient returned to inpatient rehabilitation on the day after this procedure. Bed rest was necessary for six days while the flap healed. Concurrently, a superficial stage-two right heel pressure sore and a midline gluteal pressure sore were observed. These areas were treated with a pressure-relieving multipodis ankle-foot orthosis, and frequent repositioning on a water mattress, respectively. Bedside therapies were initiated at this time. Despite this period of bed rest, no functional mobility losses were observed when cleared for out-of-bed activities. A small, clean area of wound dehiscence was observed one week after the gluteal wound revision, and this was initially managed conservatively. As her mobility improved, and the risk for wound soiling decreased, the urethral catheter was discontinued.

One month after the hemipelvectomy, a two and one-half inch left-sided external shows lift was provided to compensate for three-inch leg length lengthening on the right, to facilitate swing through on the right during walker ambulation. As ambulation progressed, right leg edema increased. Venous doppler studies were negative three weeks after inpatient rehabilitation readmission, that is, five weeks after hemipelvectomy, and three weeks after the gluteal flap revision.

At this point, she returned again to the operating room for wound closure. A right gluteal myocutaneous flap was performed. Intraoperative bacterial cultures from the wound site were remarkable for enterococcus, and subsequently this was treated with unasin and ciprofloxacin. On the sixth day after the second wound revision, she returned to inpatient rehabilitation at which point she was cleared again for out of bed activities for one hour, twice daily, toe touch weight bearing on the right leg using the pressure relieving ankle foot orthosis. She required 25% assistance to transfer out of bed with a trapeze; a right semi-rigid knee immobilizer facilitated weight shifting activities.

Seven weeks after the hemipelvectomy (two weeks after the second wound revision), RC developed a vesicular rash

on the left posterior thigh associated with neuropathic pain radiating into the left foot, consistent with a secondary herpetic varicella cutaneous infection. This was treated with oral antiviral agents for seven days and topical drying agents. Gabapentin and amitriptyline were continued at the previous doses to treat the neuropathic pain which was now in both legs. Despite interference with remobilization during the early phase of the herpetic rash, she continued to progress slowly in the rehabilitation program.

The patient spiked a fever to 102° nine weeks after hemipelvectomy and one week after the second wound revision. The fever was associated with diarrhea, despite the use of immodium. Subsequent investigation including abdominal and pelvic computerized tomography (CT), lower limb ultrasound, blood/urine/stool cultures, and stool titers for *Clostridium difficile* revealed a pseudomembranous enterocolitis, which subsequently was treated with intravenous metronidazole for ten days. Several days of fever to 102 associated with anorexia, diarrhea, and left lower quadrant abdominal pain prevented consistent participation in therapies and imposed bed rest for four days. When therapies were resumed, she was noted to have further loss of function so that she required 50% assistance with out-of-bed transfers and 25% assistance to ambulate 15 feet with a walker.

At this point she was stable enough to take a six-hour pass for family events, with the assistance of family members. She progressed well in therapies and one week after completing metronidazole she required 10% assistance with out of bed transfers and ambulated with a cane 50 feet with a pressure relieving ankle foot orthosis and a semi-rigid knee immobilizer. These devices were replaced with a custom molded knee ankle foot orthosis (KAFO).

Diarrhea recurred about one month after completing metronidazole, and stool titers were again positive for *Clostridium difficile*. Metronidazole was then restarted and given for two weeks. Despite this, she was able to maintain the functional level achieved so far. The KAFO induced a previously healed stage-two pressure sore at the right heel about one week after initiating its use, thus the pressure relieving ankle foot orthosis-knee immobilizer combination were used again during ambulation trials. The focus in therapy shifted toward intensive family during the final week before being discharged home. At the time of discharge which was at 15 weeks following the hemipelvectomy, the patient was independent during out-of-bed transfers and ambulated 75 feet with a cane. Follow-up stool titers were negative. Twice daily wound care was necessary for a stage two 2 × 2 cm right heel pressure sore and a non-healing stage-two 3 × 4 cm sacral pressure sore. The latter was the major source of persistent pain, but was well-controlled on a stable dose of long acting narcotics. Full home services were ordered including daily nursing for supervision of wound care that was being performed by family members, physical therapy three times weekly, occupational therapy twice weekly, and a home health aide for one hour daily. Home durable medical equipment included a semi-automatic hospital bed with trapeze attachment, bedside commode with an elevated toilet seat, lightweight custom-

ized manual wheelchair with a ROHO cushion, and a shower/tub seat combination. Although the patient had previously lived alone, family members chose to live-in 24 hours per day during the immediate post-discharge period. Discharge medications includes an extended release morphine 30 mg every 12 hours, an intermediate release morphine 30 mg every six hours if needed for breakthrough pain, amitriptyline 25 mg at bedtime, estrogen 0.25 mg daily for osteoporosis, cholestyramine 8 gm every morning to control loose stools, and enteric-coated aspirin 325 mg daily for thromboembolic prophylaxis. Gabapentin was no longer necessary to control neuropathic pain.

Ten days after discharge home, RC was readmitted to the hospital via the emergency room with increased swelling and pain in the right lower limb. Venous ultrasound revealed thrombus involving the proximal right thigh veins. She was heparinized with close monitoring of the platelet counts and then treated with coumadin. She was sent home after a ten day stay with a therapeutic INR. All home services were resumed and functional losses from the bed rest were quickly reversed.

RC remained at home and participated in home therapies uneventually for about three more weeks. She was readmitted to the hospital via the emergency room again, approximately six months after the hemipelvectomy and six weeks after discharge from rehabilitation, with increased swelling and more pain in the right lower limb despite therapeutic coumadin levels. Repeat venous doppler studies revealed recannulization through the already existent areas of clot. Pelvic, abdominal, and chest CT revealed a right lower lobe lung nodule, eroding into the adjacent rib, consistent with a metastatic lesion. The most likely explanation for the increasing pain and swelling in the right lower limb was lymphedema, given the remote history of radiation treatments for cervical cancer, a hemipelvectomy six months prior, and the recent proximal venous thrombus. Coumadin was continued at therapeutic levels. Pain control became extremely problematic with increasing right lower limb pain, but with stabilization of swelling to 2 to 3+ edema to the inguinal fold. Treatment options that were considered included surgical resection of the solitary lung nodule, and a right hip disarticulation. This latter option was considered given the escalation of pain in the right leg, as well as its increased weight now interfering with remobilization in therapies. Peripheral intravenous nutritional support was started in preparation for possible future surgical procedures. On the tenth hospital day of this current readmission, RC spiked a fever to 102 associated with dysuria and diarrhea. Investigation revealed recurrent pseudomembraneous enterocolitis treated with oral metronidazole. Ongoing attempts to remobilize in physical therapy demonstrated 50% assistance to roll in bed and 50% assistance to sit up from the supine position. Her unsupported bedside sitting tolerance was only five minutes at this point. Out of bed transfers and ambulation continued to be impossible because of the pain and heaviness of the right leg. In an effort to achieve better pain control, extended release morphine was increased. Subsequently, she became delirious and febrile

again. Subsequent investigation revealed positive blood cultures with staphylococcus epidermidis, presumably because of sepsis from the peripheral intravenous line, treated with intravenous vancomycin.

On the third day after starting vancomycin, the patient's fever curve started to normalize but several episodes of vomiting occurred. This was soon followed by an episode of respiratory distress with hypoxemia. A chest radiograph revealed a right lower lobe infiltrate from presumed aspiration. She was transferred to the critical care unit for mechanical ventilation. During the critical care stay, intravenous vancomycin was continued to treat line sepsis. Ceftazidime and metronidazole intravenously were added to treat the aspiration pneumonia. The critical care stay was remarkable for recurrence of diarrhea and clostridium difficile stool titers subsequently were again positive. Subsequent flexible sigmoidoscopic exam revealed a severe pseudomembraneous enterocolitis. Intravenous rifampin and vancomycin orally were added to the antibiotic regimen to treat the recurrence of the enterocolitis. For persistent bloody diarrhea, transfusions and a rectal tube became necessary, and vancomycin was administered rectally instead of orally. Throughout the critical care stay, she remained reasonably alert and responsive with resolution of the delirium about 72 hours after stopping the narcotic analgesics. She was weaned from the mechanical ventilator over two weeks, and during this time, the diarrhea continued. The non-healing sacral pressure sore progressed to a stage-four lesion and continued to be a major source of pain. About one month after this readmission, she was moved out of the critical care unit. Clinical and videofluoroscopic swallowing evaluations were unremarkable. Oral caloric intake was restarted. Despite ongoing parental nutrition, serum prealbumin levels were below the normal range. She continued a slow recovery.

The surgical treatment options for the lung lesion and the lymphedematous extremity were reconsidered realizing high surgical mortality risk after the recent life-threatening series of events. Prior to pursuing surgical interventions, it was decided to repeat a chest CT for comparison to the study done six weeks prior. This revealed the continued presence of a right lower lobe lesion and a new left lower lobe lesion, suggestive of more metastatic disease. During this time, oral caloric intake increased, however, out of bed activities and physical therapy continued to be impossible. Further recommendations for resection of the lung lesion and hip disarticulation were abandoned, particularly with the estimated high probability of disease recurrence, assuming the lung lesions proved to be metastatic osteosarcoma. A decision for enteral feedings via a percutaneous endoscopic jejunostomy tube was deferred. She was discharged home with full hospice services and family support about two months after the recent readmission and one month after the critical care discharge, approximately eight months after the hemipelvectomy. Pain, particularly from the sacral pressure sore, was adequately controlled with 15 mg ER morphine every 12 hours and MSIR 30 mg every six hours, particularly before wound care. The patient died at home six weeks

Table 1. The deconditioning syndrome

Organ system	Related complications	Prevention/treatment interventions
Musculoskeletal		
Joint contractures: arthrogenic soft tissue contracture myogenic contracture	Interference with self-care and ambulation Pathological fractures	Proper positioning of limbs in bed and while sitting, sometime with static splinting Passive and active range of motion exercises with terminal stretch at least twice daily
Muscle weakness and atrophy with depletion of anaerobic fuel sources	Decreased strength, coordination, and balance	Joint mobilization techniques Dynamic splinting Graduated sitting and standing protocols
Osteoporosis		Conservative isometric and isotonic strengthening exercises Self-care training
Integument		
Skin atrophy and subcutaneous tissue ischemia	Pressure sores	Optimize nutritional intake Frequent repositioning Specialized mattresses that unload weight bearing sites Graduated sitting and standing protocols Appropriate wheelchair size and accessories that enhance postural control and unload weight bearing sites
Cardiovascular		
Increased insensitive fluid loss, and reduction of blood and plasma volume	Postural hypotension Poor endurance during basic functional activities	Graduated sitting and standing protocols, e.g., tilt table when severe Progressive ambulatory protocols
Decreased intravascular smooth muscle tone	Deep venous thrombosis (DVT) and pulmonary embolism	DVT prophylaxis/ankle pumps Conservative isotonic strengthening exercises, especially low resistance/high repetition, with interval training
Increased resting heart rate, as well as heart rate response during submaximal exercise		Ventilatory muscle training
Elevation of systolic blood pressure		
Reduced stroke volume		
Decline in cardiac output		
Stasis of blood flow		
Increased blood coagulability		
Endocrine/metabolic		
Insulin receptor resistance	Glucose intolerance	Serum glucose electrolyte, and protein monitoring
Increase in serum parathyroid hormone	Osteoporosis	Optimize fluid and nutritional intake Graduated sitting and standing protocols
Decrease in androgen level and spermatogenesis	Low libido/erectile dysfunction	Progressive ambulation
Interruption of female sex hormone feedback loops	Amenorrhea	Conservative isometric and isotonic strengthening programs
Proteinuria	Proteinuria	
Calcemia	Calcuria	
Increased daily nitrogen loss, and associated hypoproteinemia from muscle atrophy		
Negative calcium balance with normal serum levels, thought to be primarily from muscle atrophy		
Decrease in phosphorus, sulfur, sodium and potassium		
Genitourinary		
Urinary stasis	Urinary tract infection/urosepsis Voiding dysfunction Bladder/renal stones	Bedside commode Portable urinal "Bathroom privileges" on activity orders
Respiratory		
Diminished tidal volume, minute volume and maximal breathing capacity	Aspiration pneumonia Ventilation-perfusion mismatching with arterial blood gas abnormalities and arteriovenous shunting	Incentive spirometry Percussion and postural drainage Ventilatory muscle training
Reduced cough and bronchial ciliary activity and poor clearance of secretions		Dysphagia assessment and aspiration precautions

Continued

Table 1. The deconditioning syndrome (continued)

Organ system	Related complications	Prevention/treatment interventions
Gastrointestinal		
Atrophy of intestinal mucosa and glands	Loss of appetite	Optimize fluid and nutritional intake
Slower rate of absorption of protein and electrolytes	Distaste for protein rich foods	Limit use of narcotics and anticholinergic agents
Inhibition of peristalsis	Constipation	Bowel training programs using fiber-rich foods, stool softeners, bulk forming agents, and cathartics
Neural		
Sensory deprivation	Delirium	Reality orientation
Confusion and disorientation	Impaired balance and coordination	Psychological support
Anxiety and depression		Sitting/standing protocols
Decrease in intellectual capacity	Sleep disorders	

after this most recent discharge or about ten and one-half months after the hemipelvectomy.

Discussion

The two patients reviewed demonstrate sharply contrasting clinical courses. The patient described in Case Study #1 was young, required less complicated surgery, and had a relatively uncomplicated recovery trajectory. The patient described in Case Study #2 was elderly, required more aggressive surgery, and had a complicated, and eventually, pre-terminal clinical trajectory. General rehabilitation issues that are salient in both cases include deconditioning and pain management. Hemipelvectomy-specific clinical issues include altered gait mechanics, altered sexual function, and edema/lymphedema management. These will be discussed below.

Deconditioning

Deconditioning is a syndrome comprising the reversible negative anatomic and physiologic effects that occur with bed rest, inactivity, and sedentary life styles. It involves all organ systems. It can be viewed here as a side effect of a necessary treatment, namely, bed rest during the post-surgical period. Most post-surgical rehabilitation involves the reversal of deconditioning with specific medical and rehabilitation interventions. The deconditioning syndrome and routine treatments are summarized in Table 1 [1].

Deconditioning was common in both cases. The patient presented in the first case study had a progressive one-year period of declining activity. The central component of her post-surgical rehabilitation was reversing these effects with progressive remobilization. The patient presented in the second case study was reasonably active until the time of surgery. However, she was elderly and so sustained the irreversible physiologic effects of aging. This results in compromised physiologic adaptational responses under stressful conditions, superimposed by the reversible effects of deconditioning. Her compromised physiologic status was further reduced by a series of cumulative medical events resulting in death.

Pain management

Palliative care specialists have taught clinicians to manage malignant and non-malignant pain emphasizing several important principles:

- 1) Narcotic analgesics should be used to support optimal functioning and mobility. Pain control with minimal sedation must be linked to functional performance. Pre-medication with short-acting narcotic analgesics before therapy sessions is a good example of optimizing pain management during rehabilitation.
- 2) Narcotic analgesics should be made available to patients on a regimented and standing schedule which the patient controls. Providing standing doses of long acting agents in combination with short acting narcotic analgesics, while monitoring for sedation and allowing the patient to have the privilege of refusal. This creates a better balance of care provider-patient interactions. This manner of narcotic management supports a relative degree of patient empowerment in a situation where they clearly are not in control. Further, this strategy reduces patient anxiety regarding adequacy of pain medications, which can be a factor that can amplify the patient's perception of pain. This mode of pain management will also stabilize the patient's narcotic requirements time. The use of long acting, standing doses of narcotic agents such as MS Contin and Oxycontin, typically given every eight to twelve hours, in combination with shorter acting "rescue" agents such as intermediate-reacting morphine sulfate (MSIR) or oxycodone, illustrates this principle. When a patient is approaching the maximal recommended dose of short acting narcotic analgesics over 24 hours (for example, MSIR 30 mg every four hours or oxycodone 10 mg every four hours), converting the short acting agents into longer acting, sustained release preparations, but keeping the short acting analgesic as a "rescue" agent, is recommended. Conservatively, this conversion initially should result in the sustained release preparation covering 50 to 75% of the daily narcotic. A re-evaluation of pain control every day results in the sustained release preparation covering 90% of the daily narcotic re-

quirements, with the patient continuing to use the “rescue” agent in an activity-specific manner, to treat breakthrough pain that interferes with specific functional activities and therapies.

- 3) Different pain generators should be defined and treated appropriately. Narcotic analgesics and high doses of acetaminophen (beware liver toxicity) treat musculoskeletal, neuropathic, and visceral sources of pain. Non-steroidal anti-inflammatory agents (beware gastric and renal toxicity) treat bony and visceral pain generators. Low dose anticonvulsants (beware sedation) and tricyclic agents (beware anticholinergic effects) treat neuropathic pain. Short acting benzodiazepines (clonazepam) and quinine derivatives suppress muscle cramping and spasms [2].

Altered gait mechanics

Given the lack of hip stability that occurs after internal hemipelvectomy without further reconstruction, gravitational forces produce a piston, with the affected limb initially being longer by two to three inches in the cases presented. The lack of proximal bony attachment on the affected side prevents biomechanically efficient proximal motor control during the swing phase of gait. Isolated hip and knee hyperflexion to produce a “steppage” gait to compensate for the longer leg is impossible. Isolated hip abduction and pelvic elevation using quadratus lumborum and lumbosacral paraspinal muscles to allow compensatory circumduction, similarly become problematic. A simple, elegant, and practical solution is placement of an external shoe lift on the intact extremity. The shoe lift should undercorrect the leg length difference by one-quarter to one-half of an inch. This facilitates swing of the affected limb under the gravitational control of inefficient proximal muscle groups in preparation for the stance phase as graduated weight bearing occurs. With healing and the formation of deeper scar tissue as well as progressive weight bearing, the initially longer affected limb will gradually become shorter, as observed in the first case study. Over time, the lift on the intact limb is shortened as often as every three to four months, and then removed. An external lift on the ultimately shorter affected limb must be introduced. Stabilization of limb shortening may take up to a year after hemipelvectomy. During this dynamic phase, undercorrecting the shorter limb by one-quarter to one-half an inch should be adhered to. Undercorrecting the definitive lift on the shorter affected limb may produce discomfort to the patient, and correcting evenly may be necessary to compensate for proximal “give” when the patient is in stance. Finally, external shoe lifts on hemipelvectomy patients should be made of lightweight materials, such as cork, and slightly flaring the bottom of the lift for a broader base of support and to enhance distal stability and proprioceptive feedback is recommended.

Altered sexual mechanics

Strong, intact pelvic floor muscles are essential to support sexual activity, particularly sexual intercourse. For peria-

tabular tumors, the iliacus or entire iliopsoas muscle will be excised. The gluteus maximus is retracted from the gluteus minimus and medius, and the short external hip rotators are divided. For anterior exposure, the tensor fascia lata and rectus femoris are divided and retracted. Additionally, the hip capsule is excised, the hip dislocated and the ligamentum teres and the inferior acetabular ligament are incised. A hip pseudoarthrosis is created and incised muscles are surgically repaired.

The formation of scar tissue over-stabilizes the pelvis, allowing sexual intercourse to resume. However, asymmetric pelvic mechanics place an unusual amount of stress on the remaining sacroiliac joint and the lumbosacral facets resulting in back pain during or after sexual activity. The unilaterally weak pelvic floor may predispose to dyspareunia and urinary leakage during intercourse. Aggressive efforts in physical therapy over a time, must be directed toward pelvic muscle strengthening to minimize instability and hypermobility. The patient in the first case study restarted sexual activity gradually with substantial discomfort during intercourse, but eventually she had only minor discomfort during specific positions which she learned to avoid. This required the intervention of specialized physical therapists with expertise in the mechanics of the pelvic floor [3].

Edema/lymphedema management

Any lower extremity injury whether from a controlled surgical procedure or an unexpected trauma can compromise venous and lymphatic return. In the first case study, deconditioned muscles and diminished lymphatic circulation resulted in dependent edema which was expected in the early phases of remobilization. This was easily controlled with support stockings and by physiologic muscle contraction. In the second case study, several events combined to interrupt venous and lymphatic drainage, resulting in intractable lymphedema: prior radiation treatment, aggressive surgery and proximal venous thrombosis. Lymphedema occurs when there is an overaccumulation of fluid in the interstitial tissues associated with fibrotic changes in the soft tissues. These changes start in the subcutaneous fat and quickly extend deeper to involve the fascia and muscle, and superficially to involve the skin. The interstitial fluid is protein-rich creating osmotic forces that contribute to overwhelming vascular hydrostatic mechanisms that usually facilitate interstitial fluid reabsorption. Additionally, local immune mechanisms, for example, the proteolytic activity of macrophages, and lymphatic collateral circulation, become overwhelmed. The resulting lymphedematous limb in the

Table 2. Common treats of Lymphedema

Manual massage
Intermittent compression (80 to 120 mm Hg) twice daily, for 45 minutes, with limb elevated
Graded customized compression garments

second case study was too large and too painful to tolerate usual treatments of lymphedema that are summarized in Table 2. The patient was offered disarticulation as a surgical solution since the weight of the limb was interfering with reasonable mobility. The patient's critically ill course precluded the need for such a solution [4,5].

Conclusion

These cases demonstrate the challenge involved in the rehabilitation of patients who required internal hemipelvectomy to resect malignant tumors. They represent extremes of clinical trajectories, and can guide us as to what to expect when these patients survive this procedure and participate in rehabilitation as they recover. Moreover, they represent an expanding area of orthopaedic cancer rehabilitation.

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