7 Resection of Periacetabular Lesions

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7.1 Introduction

Peri-acetabular pelvic resections are demanding operations with complex indications, anatomy, and postoperative rehabilitation. Sir Gordon Gordon-Taylor of Britain in 1935 called hindquarter amputations "one of the most colossal mutilations practiced on the human frame." [1] It was attempted with and without success prior to the turn of the twentieth century with Girard of Berne documenting the first nonfatal pelvic resection for sarcoma in 1895 [2]. As the knowledge base of pelvic anatomy, oncology, and imaging technology grew, more attempts at hemipelvectomy were made, and various techniques were developed. The application of cross-sectional imaging as well as the rise of metallurgy and implant development in the 1970s expanded the indications of this operation.

Internal hemipelvectomy with limb salvage or reconstruction has become an essential operation in the armamentarium of surgical oncologists. The goals of surgery are often negative or noncontaminated surgical margins while trying to achieve maximal function. The pursuit of maximal function has often favored internal hemipelvectomy in concept as opposed to external hemipelvectomy also known as hindquarter amputation. Primary musculoskeletal tumors, metastatic lesions, trauma, and infection of the pelvis are among the common indications for this relatively uncommon procedure. The relative contraindications for the limb-sparing procedures around the pelvis have changed in the past decade. The sciatic nerve can be sacrificed while still keeping the lower extremity. Some general surgeons have not realized that involvement of the acetabulum with direction extension from a carcinoma is not a contraindication for removal.

The scope of this discussion is focused on Enneking and Dunham Classification Type 2 hemipelvectomy, otherwise known as peri-acetabular resection [3]. In comparison to Type 1 (resections about the ilium) and Type 3 (resections about the pubis), Type 2 peri-acetabular resections are relatively more challenging with regard to resection and reconstruction [3, 4]. However, careful patient selection, scrutiny of cross-sectional imaging, and evolving reconstruction techniques have collectively improved the complication profile and survival of this relatively morbid operation.

7.2 Indications

Hemipelvectomies occur with relative rarity with rough estimates approximating 1 per 1 million persons annually [5]. In their seminal paper, Enneking and Dunham described resection in patients with sarcoma of the innominate bone that failed to be treated with radiation or chemo, no evidence of metastasis, and with preoperative imaging indicating that the anatomical location of the lesion would permit resection [3]. In principle, the aforementioned indications for hemipelvectomy remain today, but advances in reconstruction and cross-sectional imaging have sophisticated and widened these indications.

Primary bone tumors of the pelvis account for approximately 15–20% of all bone tumors with osteosarcoma, chondrosarcoma, and Ewing's sarcoma constituting nearly 50–80% of all pelvic primary bone tumors [6, 7]. Osteosarcoma and Ewing Sarcoma are most often diagnosed in adolescent and young adult patients where chondrosarcoma is most often diagnosed in older patients between 40 and 75 years of age [6]. Other indications include fibrosarcoma, Langerhans cells histiocytosis, aneurysmal bone cyst, giant cell tumor, and fibrous dysplasia, although these entities require pelvic resection with much less frequency [7]. When they occur, giant cell tumor and aneurysmal bone

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cysts have a predilection for localizing about the acetabulum [8]. Metastatic lesions to the pelvis can originate from various sources, most commonly the breast, lung, prostate, kidney, and thyroid. However, many of these lesions can be effectively managed with radiation or chemotherapy, and only a minority of metastatic lesions indicate pelvic resection [9, 10]. Infection and trauma to the pelvis have been described as indications for hemipelvectomy, although they are less likely to specifically indicate a peri-acetabular resection.

7.3 Relevant Anatomy

The complex anatomy of the pelvis requires vigilance and experience from the surgeon in order to navigate the osseous pelvis, muscular attachments, intrapelvic contents, and viscera. The pelvis can be compartmentalized into the ilium, acetabulum, and pubic rami or obturator rings. The Enneking and Dunham classification of pelvic resections is based on these specific anatomical locations of resection: resections of the ilium are Type 1, resections of the peri-acetabular region are Type 2, resections of the pubic rami or obturator rings are Type 3, and resections of the sacrum are Type 4 [3]. Posteriorly within the pelvic ring, the sacroiliac joint is bounded by the sacrospinous and sacrotuberous ligaments, which are among the strongest ligaments in the body. The iliac wings extend from the sacroiliac joint, in which the inner table serves as an attachment for the iliacus muscle which eventually joins with the psoas muscle to form the iliopsoas tendon inserting into the lesser trochanter.

The sciatic, femoral, obturator, and lumbar plexus sensory nerves are vital structures to be identified and protected when operating about the pelvis. The sciatic nerve (with the inferior gluteal artery) is transmitted through the greater sciatic notch inferior to the piriformis muscle although 10% of patients have a sciatic nerve that transmits within the piriformis. The femoral nerve (with the femoral artery) lies superficial to the iliacus muscles and courses underneath the inguinal ligament to enter the anterior compartment of the thigh. The obturator nerve courses through the iliopsoas muscle over the sacral ala and is transmitted into the medial thigh through the obturator foramen.

The pelvic vasculature requires careful consideration during pelvic resections. The aortic bifurcation into two common iliac vessels occurs at approximately the L4 spinal level. The common iliac arteries then bifurcates into the internal and external iliac vessels at approximately the S1 spinal level, although these levels can vary especially in the cases of space-occupying tumors. Characterization of these vessels in cross-sectional imaging or preoperative angiography is crucial for preoperative planning as tumor can abut, displace, or encase these vascular structures. An anastomosis of the external iliac and obturator artery is known as the corona mortis which occurs in a third of patients [11]. When present, it is often found within 3–7 cm of the pubic symphysis and requires careful handling as damage to this vessel can lead to profound blood loss. The ureter courses through the retroperitoneum medial to the psoas major muscle, and it traverses medially at the level of the common iliac bifurcation, eventually inserting into the bladder.

7.4 Imaging Studies and Preoperative Planning

As aforementioned, pelvic anatomy is complex, and it is made more challenging when tumors displace structures and anatomic landmarks. Therefore, preoperative scrutiny of cross-sectional imaging is required for safe pelvic resection. Plain x-ray is limited in the setting of hemipelvectomy relative to cross-sectional imaging as it is unable to provide details that would aid in resection and reconstruction. Oftentimes, tumors can be obscured by osseous structures and underestimate the extent or size of lesions. However, they can be of utility when planning reconstructions with regard to leg lengths.

Computer-aided tomography (CT) and magnetic resonance imaging (MRI) with intravenous contrast should be completed on all patients who are under consideration for pelvic resection. CT scans have the ability to elucidate osseous details including the extent of bone involvement and extension to pelvic viscera. Contrast enhancement of tumor and vascular structures can provide crucial information for safe resection. MRI is useful in assessing the soft tissues and tumor size. Vessels, nerves, and muscles are best visualized with MRI, and it is essentially a required study in the preoperative assessment of pelvic lesions. In general, cross-sectional imaging should be scrutinized for the location and size of tumor as well as vascular and viscera involvement in order to aid resection.

Other adjunct imaging studies can be utilized including bone scan, vascular studies, and fluorine-18 2-fluoro-2-deoxy-D-glucose-positron emission tomography (FDG-PET). Three-phase bone scans can give valuable information regarding foci of metastases and blood flow to tumors. Vascular studies are critical when space-occupying lesions have distorted the vascular anatomy, and embolization of tumor vasculature can aid in reducing blood loss and defining tumor margins. FDG-PET studies are sensitive to metabolic demands of tissue, which can localize tumors and give information regarding the responsiveness to chemo or radiation therapy.

Biopsy of the lesion is often performed with a needle biopsy technique as pelvic tumors are often deep within the pelvis, precluding open biopsy. If needle biopsy is performed, minimizing the risk of contamination is critical, and the biopsy should follow a plane of future resection in consultation with an orthopedic oncologist.

7.5 Surgical Technique

Type 2 resections of the peri-acetabular region are among the most challenging orthopedic procedures, and it is associated with the highest complication rates compared to Type 1 or Type 3 resections. A utilitarian pelvic incision is utilized, which courses along the pelvic brim and anterior superior iliac spine and, in the case of Type 2 peri-acetabular resections, extends laterally down the thigh. Careful dissection consistent with an ilioinguinal approach is performed to expose the anterior and posterior aspects of the pelvis. Major nerves and vessels as aforementioned in this chapter must be identified and protected throughout the approach and resection. The ilium/supra-acetabular osteotomy is performed once the femoral and external iliac vessels are identified and protected. A myocutaneous flap is developed with the gluteus maximus muscle to access the retrogluteal contents which include the ilium, sciatic notch, and hip joint. The ischium is osteotomized above the level of the hamstring attachment. Portions of the pelvic floor and sacrospinous ligament are released to resect the peri-acetabulum.

7.6 Reconstruction Options and Outcomes

There exist multiple options for reconstruction of peri-acetabular resections including resection arthroplasty, total hip arthroplasty with massive alloprosthetic reconstruction, saddle prostheses, and various custom devices. The remaining pelvis after a Type 2 resection includes the ilium and obturator rings with discontinuity between those two structures. This void eliminates the pelvic hip articulation which can result in significant disability for the patient. Reconstruction options have attempted to address this disability in an effort to maximize function following peri-acetabular resections, although complication rates are high and approach 20–60% [12–20].

7.6.1 Resection Arthroplasty

Resection arthroplasty avoids complications associated with reconstruction. The Friedman-Eilber resection arthroplasty was described in 1979 which consisted of an internal hemipelvectomy and proximal femur resection followed by soft tissue closure. Several studies have reported that the instability due to this flail hip leads to poor ambulation and inferior patient acceptance [21–25]. However, other studies have shown acceptable function can result and has the distinct advantage of avoiding the complication profiles of prosthetic reconstruction [26, 27]. Modifications on the technique to achieve ilium-proximal femur fusion and hip transposition have been made in order to avoid flail limb with some success [28, 29]. Beadel et al. suggest that iliofemoral arthrodesis can be attempted if bone loss to the ilium is less than 5 cm and the femoral head is conserved [13]. Resection arthroplasty results in leg length discrepancies which can be overcome with shoe lifts [18, 26].

7.6.2 Pelvic Reconstruction with Total Hip Arthroplasty

Total hip arthroplasty with alloprosthetic pelvic reconstruction is one option for peri-acetabular reconstruction. Beadel et al. reported that if patients did not subsequently develop an infection, functional results were “reasonable.” [13] However, the infection rate approached 50% of reconstructed patients in their series [13]. In their series of 147 patients who underwent pelvic resections for pelvic sarcoma, Puchner et al. found that endoprosthetic reconstruction and high-volume tumors were significant risk factors for experiencing a major complication and infection [30]. Several studies have reported results on extracorporeal irradiation (ECI) and reimplantation of peri-acetabular resections with subsequent total hip arthroplasty with varying results [3–33]. A recent study of 23 patients with Type 2 resections below the anterior superior iliac spine treated with ECI and total hip arthroplasty had very good functional results, no recurrences, one dislocation, and no infections at an average of 21 months follow-up [34]. The authors attributed these promising results to their specific patient selection which was based on the levels of resection to maximize bone union after reconstruction [34].

7.6.3 Saddle Prosthesis

Saddle prostheses implant into the femoral canal and attach to the remaining ilium. The femoral preparation and implantation are, in general terms, similar in concept to femoral stems in total hip arthroplasty or hemiarthroplasty. The proximal saddle portion attaches to the ilium and is modular to help achieve correct leg lengths. Retention of hip musculature including the iliopsoas and abductor muscles is important for function and stability of the prosthesis. The clinical results of this procedure are mixed at best. Long-term results for saddle prosthetic reconstruction report poor restoration of function and substantial morbidity [35]. In contrast, Aboulfaia reported good to excellent results in 12 of 17 patients treated with saddle prostheses for peri-acetabular resections [36]. Another study noted that saddle prosthesis could provide early weight-bearing and reduce leg length discrepancy with fair functional results [37], and other studies have reported satisfactory functional outcomes [38]. However, there is a high complication rate and questions regarding the longevity of this device as proximal migration leading to limb shortening, infection, and hardware failure are common which have led some institutions to abandon this reconstruction technique [39]. From a case series of 15 patients, Renard et al. posited that results were satisfactory if certain contraindications to saddles prostheses were taken into consideration which were osteoporosis, iliac involvement, and poor soft-tissue quality [40].

7.6.4 Custom Pelvic Implants

Custom-made implants based on preoperative CTs constructed by manufacturing companies have also been utilized to reconstruct peri-acetabular voids. Rudert et al. found that in their series of 38 patients, revisions were required in 52.6% of patients with a 21% deep infection rate with poor mobility and patients requiring walking aids [41]. When applying CT-based osteotomy guides and custom implants for peri-acetabular resections, acceptable functional and oncologic outcomes were reported although with 62.5% of patients experiencing at least one complication and 25% of patients experiencing an infection [20]. The MUTARS system (Implantcast, Buxtehude, Germany) has been utilized in Germany for the last two decades with acceptable functional and oncologic outcomes but at the risk of implant loosening and infection [42]. Promising results were reported from China where modular hemipelvic prostheses for peri-acetabular resections resulted in a 14% complication rate with only one dislocation [43]. Other reports from China have also reported promising results with modular hemipelvic prostheses [44–46] as well as a report utilizing bulk femoral head autograft for pelvic reconstructions [47].

7.6.5 Pedestal Cup Prosthesis

Recently, pedestal cup prostheses have been applied in Europe with similarly mixed results in comparison to other reconstruction options. Pedestal prostheses are implanted into the ilium with a distally protruding cup to articulate with a femoral component. Bus et al. reported complications in 15 of 19 patients with dislocations, loosening, and infection as the leading causes which led them to advise caution in utilizing this construct [48]. More recently, the LUMiC prosthesis (Implantcast, Buxtehude, Germany) has been utilized in Europe which is a pedestal cup prosthesis. This prosthesis is unique in that it is coated silver to prevent infection, although infection occurred in 28% of patients. Mechanical complications occurred in 30% of patients with dislocation being common; however, once a dual-mobility cup was utilized, the dislocation rate reduces substantially to 4% [49]. The mid- to long-term results of this implant have yet to be reported. Results from the Schoellner cup (Zimmer Biomet Inc., Warsaw, Indiana) revealed similar results in that 15% of patients suffered a dislocation and 17% of patients suffered a deep infection requiring revision [50]. A somewhat similar prosthesis labeled the Ice-Cream Cone Prosthesis also utilized an ilium implant that depends on minimal to no ilium bone loss. In their series of 10 patients with minimum of 2 years follow-up, functional results were fair with wound complications and infections prevalent [51].

7.7 Complications

Hemipelvectomy is associated with a high complication rate that ranges from 20% to 60% [12–20]. Careful scrutiny of advanced imaging can help mitigate intraoperative complications which include intraoperative hemorrhage and damage to viscera or pelvic contents including the ureter, bladder, and bowel. However, pelvic resection is fraught with complex anatomy rendering this a relatively morbid operation. Postoperatively, the most common complications are wound infection and flap necrosis, and deep infections occur frequently with reconstructions. Presumably from the large surgical beds which are often open for extended durations near bladder and bowel, the infection rates following this procedure are high especially in the setting of prosthetic reconstruction. Aljassir et al. reported a 37% infection rate in a review of 27 saddle prosthetic reconstructions, and Abudu et al. reported a 60% complication rate with infection leading all others at 26% [14, 52]. In an analysis of 270 pelvic resections, 166 which were peri-acetabular, the infection rates were 26% in patients who were reconstructed and 15% without reconstruction [53]. Those patients that developed infections often required extensive treatment including conversion to external hemipelvecotomy [53]. Hardware failure, dislocation, and loss of fixation are problematic of reconstructive prostheses which have led some surgeons to abandon reconstruction in favor of resection arthroplasty.

7.8 Conclusion

Peri-acetabular pelvic resections are a relatively rare procedure performed for primary bone tumors, metastatic lesions, and with less frequency, trauma, and infection. Advanced imaging and interdisciplinary care with radiologists, oncologist, and other surgeons are necessary to safely navigate this complex surgery especially in the cases of anomalous anatomy. Due to the resultant disability of peri-acetabular resections, many techniques to reconstruct the hip have been described. However, reconstructive options are associated with a high rate of complications including wound issues and infection leading some to abandon reconstruction in favor of a flail limb. As such, future innovations to enhance mobility and reduce infection rates are necessary to improve the safety and efficacy of this potentially curative procedure.

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