Pelvis: General Considerations

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Resections of tumours of the bony pelvis are highly morbid and can challenge even the most expert of surgeons [1–5]. Decisions regarding the surgery and the ultimate outcomes of procedures are determined by the type and location of the tumour (bone or soft tissue) [4, 6–8], the operative approach [9], the reconstructive techniques utilised [1, 10–13] and the amount and type of tissue sacrificed in the surgery. The morbidity of pelvic reconstruction is high, and the intraoperative demand on expertise, resources and personnel is such that pelvic tumour surgery is best practised in a multidisciplinary team setting with members who are familiar and expert in the intra- and perioperative care of such patients [9].

1.1 Important Considerations When Planning Treatment of Pelvic Tumours

- Understanding the aetiology of the tumour (benign, malignant, primary, metastatic) will allow engagement of the relevant clinical experts, determination of oncologic surgical margins and planning of durable reconstructions.
- Comprehensive pathologic, local and systemic staging is mandatory and part of the treatment strategy of these complex tumours.
- Classification systems help to define the location of the tumour and the types of resections and reconstructions that may be required.
- A careful study of the anatomy of the pelvis in relation to the tumour and its planned resection allows anticipation and mitigation of intraoperative hazards.
- Careful planning of the surgical approach together with other specialist surgeons is critical for ensuring optimal patient positioning and draping, for achieving the best view of the operative field and vital structures, for anticipating the order of surgery when multiple specialties are involved and for facilitating the use of specialised equipment if required.
- Pelvic surgery often requires prolonged surgery that is frequently associated with episodes of haemodynamic and respiratory instability. This requires an expert anaesthetic team capable of managing rapid transfusion requirements and invasive monitoring. Managing the physiologic upset during the procedure is an important consideration and requires a close working relationship with the anaesthetic team.

1.2 Aetiology of Pelvic Tumours

1.2.1 Primary Tumours

Ten percent of primary tumours involve the pelvis, and of these, chondrosarcoma, Ewing's sarcoma and osteosarcoma are the commonest [14]. These may be treated with curative or palliative intent and, other than chondrosarcoma, will require adjuvant multimodal treatment. In either clinical situation (curative, palliative), local control of disease to minimise or negate tumour recurrence is the prime goal of surgery. If vital structures are not at risk, then wide surgical margins are indicated and may be defined as at least 2 cm of clear bone in the line of the bone and a cuff of normal tissue which is a named anatomic layer such as muscle or fascia that is parallel to the surface of the tumour [15]. Some authors have highlighted the importance of the quality of the surgical margin and that this may vary between tissues that comprise the margin [16]. In planned resections, which involve adjuvant treatment, surgery is often preceded by neoadjuvant chemotherapy or radiotherapy. Chemotherapy and radiotherapy aim to kill the tumour, reduce its size and

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incite a fibrotic reaction around the tumour to create a true capsule which effectively enhances the surgical margin. The extent of surgery including the resection of bone and soft tissue often leaves the operative bed associated with a substantial dead space. Dead space is a potential source of complications including haematoma, infection and wound dehiscence, which may demand pre-emptive or corrective surgery. Early involvement of plastic and reconstructive surgical expertise in the surgical planning will optimise surgical outcomes [17–19].

1.2.2 Secondary Tumours

Metastatic bone disease following carcinoma is a common occurrence [20, 21]. Common primary sites of carcinoma which metastasise to the pelvis include breast, lung, prostate, kidney and thyroid. Breast and prostate carcinoma metastases often present with mixed sclerotic-lytic disease. Lung carcinoma metastases often present with permeative and poorly circumscribed lesions. Thyroid and renal carcinoma metastasise with cannonball lesions that are often hypervascular and markedly lytic and may grow to considerable sizes. Metastases may also be associated with large soft tissue components, which present a similar complexity as large primary tumours by obscuring or impinging on vital structures.

The management of primary bone malignancies differs from metastatic bone disease because primary tumours are often solitary, are amenable to wide surgical margins and are resected with as large a cuff or margin of normal tissue as is possible. In contrast, the surgical management of metastatic disease, which is diffuse, progressive and multifocal, aims for conservative bone-preserving techniques that are durable and appropriate for what is often treatment with a palliative intent [20, 22]. For the latter, curettage or the removal of only macroscopically affected tissue is combined with reconstruction that is reinforced and not primarily dependent on bone union or ingrowth. Rarely, truly solitary metastases may be treated with wide resection like a primary tumour. More commonly, however, apparently solitary metastases are associated with micrometastatic lesions within the same bone, which eventually manifest their presence in the passage of time. Careful scrutiny of well-performed anatomic and functional imaging investigations should be undertaken before a decision is made to designate a tumour as solitary. Progression of metastatic disease is the norm, and to avoid failure of the device from rapid recurrence of tumour, reconstructions should be planned to achieve maximum durability within the anticipated lifespan of the patient [20, 22]. For example, internal fixation often reinforced by acrylic bone cement should span entire lengths of bones. Locking screws should be used and anchored in bone cement to enhance fixation and strength of the construct. If joint prostheses are to be used, then consideration should be given for cement fixation rather than cementless fixation, and for long-stemmed prostheses rather than standard-length prostheses for the femur, humerus and tibia for added protection.

1.3 Symptoms of Pelvic Tumours

Because of the large intra-abdominal and intra-pelvic volume, primary pelvic tumours may have an occult presentation, reaching large sizes before detection. Symptoms may vary between bone and soft tissue sarcomas with the former being associated with deep-seated and nocturnal pain, while the latter often presenting without pain. Abdominal fullness may be a feature of the latter's presentation. Irritation of the bowel and bladder or compression of the ureter may lead to obstructive symptoms, frequency or dissatisfied visceral evacuation. Often, symptoms are vague and misinterpreted for musculoskeletal injury or referred pain from the lumbar spine.

1.4 Imaging Modalities

Appropriate and adequate imaging is mandatory for surgery about the pelvis [23–25]. When dealing with tumours, both anatomic and functional imaging can be very useful for characterising the tumour and informing the planning of biopsy and surgical margins. Anatomic imaging includes plain radiography, computed tomography (CT) and magnetic resonance imaging (MRI). Functional imaging is used to examine the metabolic activity of tumours and include technetium bone scans, thallium scans and positron emission tomography. The results of functional scans can be superimposed (co-registered) onto CT scans to provide the exact location of metabolic activity in relation to the patient's anatomy.

1.4.1 Plain Radiography

Biplane and Judet views of the pelvis are simple and reliable tests that allow assessment of the bony architecture of the pelvis. These are particularly important not only for characterising the primary tumour but also for delineating bone destruction associated with metastatic disease. Digital imaging is now available in most centres, and standardised views with appropriate scaling allow more accurate templating and planning for acetabular or proximal femoral prostheses, as well as for selecting size-matched allografts.

1.4.2 Computed Tomograph

Fine-slice CT is an excellent modality for assessing the quality of bone. Not only is cortical bone very well delineated with CT, the high-resolution images available today make characterisation of subtle trabecular destruction much easier than in the past. CT scanning because of the contrast between tumour and fat easily demonstrates marrow replacement by tumour, and this may be particularly useful when investigating a potential tumour-related pathologic fracture. CT scanning can provide excellent multiplanar views from which three-dimensional images may be constructed. Computer algorithms (bone windows) that are able to suppress metal artefact allow this modality to interrogate prosthetic-bone interfaces. With more sophisticated computer software, whole prostheses within individual images may be suppressed to provide better visualisation of periprosthetic bone.

1.4.3 Magnetic Resonance Imaging

Magnetic resonance imaging is unsurpassed as a modality for imaging soft tissue. MRI should be a mandatory investigation for assessing all primary tumours of the pelvis because it combines excellent three-dimensional bone imaging with excellent delineation of organs, vessels and nerves to give a very accurate assessment of the relationship of pelvic tumour to the pelvic viscera. Moreover, MRI exploits the high water content of fat to accurately characterise the intraosseous extent of tumour.

1.4.4 Angiography

Angiography may be required to determine if vessels are compromised by a tumour and therefore need to be sacrificed, or if important feeder vessels exist and need to be embolised or ligated as part of tumour resection. Embolisation may need to be considered to avoid intraoperative haemorrhage when dealing with certain metastatic carcinomas arising from the kidney, thyroid or myeloma. Some primary tumours occur in highly vascular areas (sacrum), and embolisation may need to be performed to avoid troublesome intraoperative and post-operative bleeding. Preoperative embolisation using radiopaque coils, beads or gelfoam should be considered within 36 h before surgery to minimise the return of flow to the embolised lesion. Although traditional contrast angiography provides highly accurate images, non-invasive methods such as CT or MR angiograms may also be performed, although smaller vessels may not be as easily visualised.

1.4.5 Functional Imaging

This modality is particularly useful for metastatic screening or for determining the metabolic activity of tumours. Identifying multiple intraosseuos or soft tissue lesions has a profound impact on prognosis and will have important implications on the choice of treatment strategies. The extent of metabolic activity may also reflect the grade of the tumour. High-grade tumours are associated with high metabolic activity as compared to low-grade tumours. Of note, large malignant tumours are often associated with central tumour necrosis, and this should not be misinterpreted for low tumour grade. Biopsies are most representative when tissue of the highest grade and greatest viability is obtained. Functional imaging is excellent for identifying regions which may be targeted for biopsy. Post-treatment activity is also a measure of tumour response, and this may have important implications when planning surgical margins. Primary bone tumours with a good response to chemotherapy but close margins have a five times higher risk of local recurrence than tumours with a good chemotherapy response and good margins [26]. Tumours with a poor response and poor margins have a 50 times higher risk of local recurrence [26]. Knowing this information prior to surgery may help to discuss the pros and cons of amputation versus limb-sparing surgery.

1.5 Anatomic Considerations

The anatomy of the pelvis is complex. Imaging information from CT and MRI scans allows a good understanding of the relationship of the tumour to pelvic and intra-abdominal structures. Prominent tumours may distort anatomy, and structures most at risk include vessels, nerves and the ureters. Often small, these structures may be injured when dissecting around areas where the anatomy cannot be clearly defined. Prior to surgery, planning of surgical margins and the surgical approach should include a review of the pelvic anatomy, which should be orderly, beginning from the posterior pelvic ring and passing forward to the pubic symphysis.

1.6 Anaesthetic Considerations

Anaesthesia for pelvic surgery is challenging because of the extensive tissue trauma, the prolonged operative time, exposed bleeding bone and, in the case of malignancy, the impact of neoadjuvant therapies [27]. Post-operatively, patients face a number of major physiologic insults including ongoing blood and fluid loss, the effects of massive blood transfusion, ileus and pain. Typically, post-operative pain is severe, and multimodal anaesthetic techniques are required

to provide safe and effective analgesia. While much has been written about pelvic resection and reconstruction, little is reported about the anaesthetic techniques employed in the surgery for these patients.

In well-planned surgery, preoperative anaesthetic assessment begins sometime prior to the scheduled surgery date. Ideally, the patient is seen by the anaesthetist, but patients from somewhere a great distance from the hospital may be contacted by telephone consultation.

While preoperative assessment includes a routine review of all systems, of particular importance is knowledge of location and pathology of the tumour and type and impact of preoperative adjuvant therapy. An understanding of the type, location and size of tumour helps the anaesthetist assess the possible extent of surgery required. For example, large tumours requiring extensive resection with close proximity to vascular structures will be more likely to have larger blood loss, greater tissue trauma and need for intensive postoperative support than those which are smaller and in a more favourable surgical position. Tumours that are situated posteriorly in the pelvis more often involve complicated and prolonged dissection around the lumbo-sacral plexus. The internal iliac vessels are more likely to be troublesome when tumours are situated posteriorly in the pelvis. Equally, anterior pelvic tumours that require dissection near the bladder neck are challenging because of the great tendency for the perivesical venous plexus to bleed heavily or continuously. Osteotomies expose bleeding bone and can provide a sustained source of haemorrhage. In anticipation of major blood loss during surgery, the hospital blood transfusion service should be notified of the date of surgery and the amount of blood and blood components that may be required. In most hemipelvectomy cases, ten units of packed red cells, five units of fresh frozen plasma and five units of platelets should be available at the commencement of surgery.

Preoperative chemotherapy or radiotherapy may have a deleterious effect on bone marrow function. Complete blood examinations are therefore required to ascertain if anaemia, profound leucopenia or thrombocytopenia exists. Consultation is made with the patient's oncologist to determine whether the haematological disturbances will correct themselves prior to surgery or whether further specific treatment is required. The hospital intensive care unit (ICU) is also notified at this stage of the date and type of surgery, as well as the possible duration of stay in ICU, so that resources can be allocated in advance.

1.7 Positioning and Pressure Care

As with any prolonged surgery, careful attention needs to be given to prevention of peripheral nerve compression. The patient should be positioned in the lateral position with the side supports holding the upper body at the sternum and mid-thoracic region well clear of the flank and abdomen. This allows the patient's body to move through an arc of 90°, from −45° to +45° when the operating table is rolled laterally from left to right side. The benefit of this position (floppy lateral) to the surgeon is that the rolling manoeuvre allows both anterior and posterior parts of the pelvis to be accessed. The potential hazards for the patient are that the points of potential nerve compression change each time the patient is moved as well as a risk of breathing circuit disconnection or dislodgement. Checking by the anaesthetist of areas at risk of compression neuropathy needs to be performed each time the patient is rolled from one side to the other.

1.8 Post-operative Analgesia

The method used for post-operative analgesia will be dependent on the technique chosen for anaesthesia. In our institution, a combination general and spinal anaesthetic and a post-operative epidural catheter with a continuous infusion of anaesthetic/opioid is preferred. The infusion is usually commenced in the intensive care unit or recovery room once the patient is haemodynamically stable. The infusion may be extended for up to 6 days. It is important that endotracheal intubation rather than laryngeal mask intubation is used because massive transfusion may cause subglottic and supraglottic oedema which is more safely managed using an endotracheal tube rather than a laryngeal mask. In the post-operative period, further bleeding can be expected. As an estimate, approximately one-third the volume of intraoperative fluid replacement is required in the first 24 h post-operatively.

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