Preoperative Planning

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All those surgeries of sacral sarcoma are defined as confined operation. The purpose of preoperative planning is to help surgeons get a better understanding of the surgery and help patients prepare themselves for the surgery and recover from it as soon as possible.

Before the preparation of the surgery, surgeons need to study the case discreetly and comprehensively through local plain film, computed tomography (CT), and magnetic resonance imaging (MRI), from which they could plan detailed surgical procedures and steps. Angiography should be undertaken if there might be involvement of the vessels [1]. Sacral tumors usually grow toward the presacral space and present with extremely large dimensions. Digital subtraction angiography (DSA) is thought to be not only a means of examination but also a treatment option, through which surgeons could not only observe the blood supply of the sacral tumors but also embolize the arteries which feed the pathological lesion with most appropriate embolic agent [2]. Occlusion of the vessels decreases the volume of the tumors, but multiple procedures are frequently needed [3].

Although the majority of these tumors are benign, they may become locally aggressive, causing catastrophic neurological impairment and weakening pelvic arch stability. For benign tumors, such as schwannoma, neurofibroma, giant cell tumor, and so on, the standard treatment is intralesional curettage followed by some other adjuvant therapy [4, 5]. However, for malignant or local aggressive tumors, like osteosarcoma, chordoma, chondrosarcoma, and so on, the initial en bloc resection of those tumors may give the patient the best chance of long-term survival [6]. However, surgical procedures might be complicated due to the complex anatomical characteristics of this region, the huge tumor volume, and the abundant blood supply. Besides, the requirement for adequate tumor removal must be balanced against the preservation of nerve function, which all influence surgical margins of those tumors and made local control of those tumors difficult. The conventional transperitoneal approach often requires retraction of abdominal organs for a long time during operation [7], which might had an impact on patients' postoperative recovering. In addition, it is difficult to acquire a sufficient clear absolute visual field to perform the surgery; thus, usually a larger incision was adopted, which resulted in longer rehabilitative time for the wound. Moreover, the lengthy retraction time might increase the possibility of organ or vessel damage. It is possible for surgeons to choose a single posterior approach to complete the surgery of sacrum with satisfactory result [2, 8–11]. Some doctors thought it might be more convenient to use one-stage anterior and posterior combined approach when patients presented with larger tumor [5, 9], while we thought it might not be necessary. With years of practice, the procedure with posterior-only approach brought us local recurrence rate of 18.9% in our 130 cases of sacral giant cell tumors, far lower than incidence of 47% reported in the literatures [12], which, in our opinion, relied on wide resection of most part of tumors and effective control of intraoperative hemorrhage. As we all know, enhanced local tumor control and overall survival could be acquired by wide resection of tumors despite potential complications and neurologic dysfunction [6, 13]. Total sacrectomy is indicated when a malignant or aggressive benign lesion involves the proximal sacrum with anterior extension [14]. Partial sacrectomy is used for tumors with substantial involvement of the sacrum below the S2 segment, which can usually be resected with wide margins and allows patients to maintain bowel and bladder functions without lumbopelvic reconstruction [5]. If complete resection could not be achieved easily, serial arterial embolization and radiation therapy are alternatives [15]; however, because of the limitations of technical merits, it is usually palliative with poor tumor control in China.

Massive retroperitoneal tumor usually involves the ureter, colon, rectum, and some other retroperitoneal viscera. And it is quite common to do urethral shunt, nephrectomy, as well as colectomy first before the actual surgery of the tumor.

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Given the possibility of tumorous involvement of the ureter, catheterization of double-J tube into the ureter of the affected side is necessary. It is appropriate to estimate the blood loss according to individuals' neoplastic condition and take actions to avoid complications. A consultation of general surgeons or urological surgeons is necessary if there is probability of colectomy or bladder bypass surgery. Not all the patients need colectomy; thus, we could not give a clear definition of operative indications of colectomy for sacral tumor. The independent risk factor for early-stage infection of these surgeries is urogenital bacterial and fungal infection, which should be taken into prevention before surgery [16].

24.1 Conventional Preparation

Preoperative communication with patients and their family members should focused on their expectations about surgical and anesthetic procedures, which mainly contributed to diminishing fear and anxiety and better understanding of postoperative recovery [17]. Face-to-face counselling, leaflets, or multimedia information containing explanations of the procedures along with tasks which contain encouragement might facilitate perioperative feeding, early postoperative mobilization, and pain control, which hence reduce the prevalence of complications [18]. Ideally, the patient should meet with the surgeons, anesthetists, and nurses one by one.

Preoperative evaluation should be used to identify medical conditions and risk factors for postoperative morbidity and mortality. Optimization of anemia, diabetes mellitus (DM), and hypertension improves outcomes [19–22]. It is necessary to have a comprehensive understanding of patients' general condition including mental and nutritional condition; the basic function of the heart, lung, liver, kidney, endocrine system, and blood; as well as immunity, from which we could find out various potential factors that may influence the surgery.

Before surgery, patients should be advised to stop excessive smoking or drinking. A recent review upon 11 randomized controlled trials (RCTs) involving 1194 patients concluded that smoking cessation during perioperative period appeared to contribute to reduce perioperative complications [23]. Several other studies have described the association between hazardous intake of alcohol and an increased morbidity because of postoperative infections, cardiopulmonary complications, or bleeding episodes [24].

A recent RCT [25] showed that "prehabilitation" (a program designed to increase functional capacity in anticipation of an upcoming stressor) addresses the impact that physical exercise might have on postoperative functional exercise capacity. The effect of such program regarding outcome remains to be evaluated [26]. Although we encouraged patients to get out of bed and walk as soon as possible after surgery, all those who went through surgeries of sacral tumors experienced huge trauma and sometimes were too weak to get out of bed postoperatively. Thus we need them to practice defecating and urinating at bed a few days before the surgery. What's more, some exercises to strengthen the muscle need to begin before surgery, which means a lot for patients in psychological acceptability [26].

It has been shown that pharmacological prophylaxis against venous thrombosis (VT) reduces the prevalence of symptomatic venous thromboembolism (VTE) without increasing side effects such as bleeding [27]. In addition, use of compression stockings reduces the incidence of VTE [28]. Patients with extensive comorbidity and malignant disease who are taking corticosteroids preoperatively and who have undergone previous pelvic surgery and those in hypercoagulable states have an increased risk of VTE. However, bleeding during or after the sacral surgery is also a life-threatening catastrophe for those patients [1, 13]. Thus prophylaxis against deep venous thrombosis of lower limbs may give way to preventing massive bleeding in the first 1–2 days after surgeries and these prophylactic treatment might be delivered 2–3 days later. In a recent Cochrane report based on four RCTs (n = 1021), it was concluded that prolonged (4 weeks postoperatively) VTE prophylaxis as compared with in-hospital prophylaxis was associated with a significantly reduced prevalence of VTE (14.3 vs. 6.1%, $p < 0.0005$), as well as symptomatic VTE (1.7 vs. 0.2%), without an increase in postoperative bleeding complications or other side effects [27]. We encourage the using of compression stockings to reduce the incidence of VTE. But as for pharmacological prophylaxis, it should depend on the detailed situation of each surgery and the general condition of each individual.

Considering the length of this chapter, we focus on the exceptional preparation for sacral surgeries.

24.2 Preoperative Bowel Preparation

Because of the long duration of sacral surgeries (usually longer than 6 h) as well as massive hemorrhage during operation (blood transfusion exceeding 2000 ml), the preoperative comprehensive evaluation is essential for those patients, mainly on metabolism and the cardiovascular and respiratory system. If the patients' condition is too weak to endure such a surgery, it is more appropriate for the patient to receive radiotherapy rather than to do the surgery. Insufficient preoperative preparation might increase intraoperative bleeding, which could further result in unclear surgical version and unsatisfactory surgical margins for those tumors, which of course further cause disappointed oncologic or functional prognosis. Sometimes even more seriously unsatisfactory preoperative preparation could indirectly lead to patient's death.

The most job of preoperative preparation is intestinal preparation, including using enema and oral laxatives. It is quite common to resect part of the small intestines or colorectum for a sacral surgery because of the neoplastic invasion or adhesion. However, mechanical bowel preparation (MBP) is associated with dehydration and changes in electrolyte balance (particularly in the elderly). A meta-analysis from studies focusing on colonic surgery showed no clinical benefit from MBP [29, 30]. Our patients usually stay at younger age than those with colorectal cancers, dehydration and electrolyte imbalance may be corrected more quickly. We usually combined oral laxatives and enema to prepare the intestinal in order to avoid postoperative wound or other infections. Fasting from midnight has been standard practice in the belief that this reduces the risk of pulmonary aspiration in elective surgery. What's more, our patients even started fluids 2 days before the surgery and oral laxatives 24 h before the surgery [5]. Cleansing enema may be needed at the morning of surgery. If it is estimated that intestinal surgery could not be avoided, preoperative fasting could be as early as 2 days before the surgery with parenteral nutrition.

The estimation of amount of bleeding for the surgery of sacral tumors depended on the location of the tumors, histological types, and the experience of the surgeons [1]. Generally speaking these operations last for a long time and need massive transfusion. Some benign tumor could use autologous stored blood transfusion [31], while majority of these cases require abundant blood storage in case of massive hemorrhage intra- or postoperation. If it is estimated that the blood loss would reach 2000 ml, fresh frozen plasma should be prepared for fear of coagulation disorders (the estimation of amount of blood loss can be seen in Table 24.1 [1]). However it is only preoperative estimation which should be adjusted according to the actual situation during surgery.

Table 24.1 The estimation of the amount of hemorrhage for the surgery of sacral and pelvic tumors [1, 31]

Operation region	Blood loss during surgery (ml)	Blood loss after surgery (ml)
Traditional hemi-pelvic amputation	800–3500	300–600
Hemipelvectomy	1500–5000	300–800
The resection of RegionI[a]	400–2000	200–300
The resection of region II[a]		
Endo-prosthesis	1500–3000	400–600
Arthrodesis	2000–4000	300–600
The resection of region III[a]	400–2000	100–300
Partial sacrectomy	1000–3000	400–800
Total sacrectomy	3000–6000	400–1000

[a]According to [32]

24.3 The Techniques to Reduce Massive Hemorrhage During Surgery

Massive bleeding during sacral surgery can rapidly destabilize a patient. Thus, effective hemostasis is critical due to the fatal course of this complication. Reported methods included packing, thumbtacks, inflatable devices, muscle tamponade, muscle fragment welding, and so on [33]. Local hemostatic agents in conjunction with other methods such as diathermy, cyanoacrylate tissue adhesives, and application of bone wax are also available alternatives. However, we don't think all those mentioned above could effectively control massive bleeding during sacral surgery. Whereas complications related to massive blood infusion, such as coagulopathy, hypothermia, and hypocalcemia might cause morbidity, although rare, but possible [1]. Bleeding can be so extensive at times that complete tumor resection becomes impossible. Blood cell salvage has been used to diminish the requirement for autologous blood transfusion but is not recommended in malignant tumor surgery. Thus, the key to the success of these surgeries is to manage intraoperative hemorrhage. We mainly use three methods to control intraoperative hemorrhage, including preoperative embolization of the tumor-feeding arteries under digital subtraction angiography (DSA), ligation or temporary blocking the affected internal iliac artery and application of a balloon dilation catheter (BDC) [34].

1. Digital subtraction angiography and selective arterial embolism.

   It is highly applicable to do embolization of the tumor-feeding arteries under digital subtraction angiography before surgery, which could not only make the local lesion explicited but also effectively reduce intraoperative hemorrhage [8]. Thus we do DSA and selective arterial embolism routinely for those complicated huge sacral tumors, especially for those hypervascular tumors, such as giant cell tumors (Fig. 24.1), aneurysmal bone cyst, and so on.

   However, so far as we know, the effect of SAE is not satisfactory [35]. Besides, embolization is not always practical in sacral surgery for multiple arteries supply blood to the pelvis and sacrum. Embolizing only the lateral common iliac artery or the internal iliac artery will not completely block the blood supplying the tumor. Besides collateral circulation is usually reestablished within 24 h after embolization [12], tumor resection should be scheduled soon afterward. In addition, some serious complications after embolization have been reported, including neurological deficits and pain. Sometimes the embolization could even lead to wound healing problems. Therefore, we usually choose another

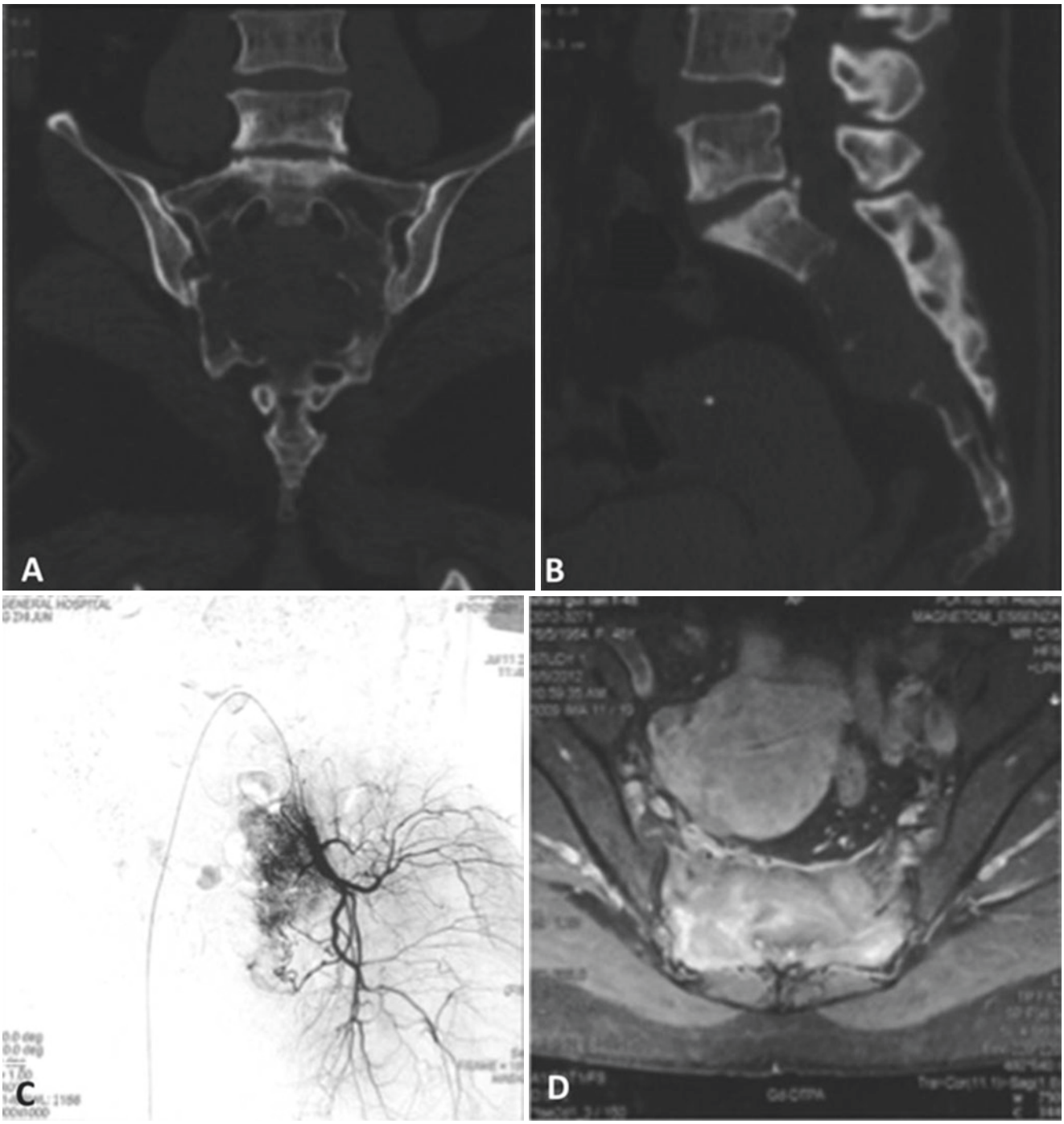

Fig. 24.1 The radiographs of a 48-year-old female patient with sacral giant cell tumor who presented with lumbosacral analgesia for nearly 1 year. (**a**–**c**) showed the CT and MRI manifestation of tumor. (**c**) Digital subtraction angiography showed the hypervascularity of this tumor, and selective arterial embolism was done several times before the surgery. (**d**) The MRI of the local lesion showed the involvement scope of the soft mass

way to control intraoperative hemorrhage such as ligation of affected internal iliac artery and using tape to temporarily block abdominal aorta from anterior approach during surgery.

2. The ligation of affected internal iliac artery and temporary abdominal aorta occlusion (detail seen in Chap. 33).
3. The application of a balloon dilation catheter (BDC) to temporarily block the abdominal aorta (detail seen in Chap. 33).

However there are still some notes special for balloon occlusion. First, to reduce the risk caused by resettlement of

the balloon, preoperative ultrasound should be routinely performed to figure out the condition of bilateral femoral artery, external iliac artery, and abdominal aorta. As to elder patients, ultrasound or CTA is especially recommended to exclude vascular disease such as atherosclerotic plaque and vascular malformations, in case of rupture of blood vessels during the placement of the catheter. Second, air in the balloon must be completely evacuated before the catheter is introduced. Liquid was used to inflate the balloon to avoid air embolism in case of balloon rupture during the operation. Third, after the balloon catheter is placed and fixed in position, ultrasonic examination should be available to reconfirm that the balloon is located between the renal arteries and the abdominal bifurcation and that the two renal arteries have not been occluded by the inflating balloon. If the balloon's location is too high, it may cause spinal cord ischemic injury and/or renal ischemia. If urine output is <0.5 ml/kg h, the position of the balloon may be too high and may require an adjustment [36, 37]. The duration of each occlusion should be limited to 1 h to prevent ischemic damage to the spinal cord, pelvic organs, and lower extremities.

Though low-pressure anesthesia has been used for controlling blood loss in resection, it has high demand for intraoperative monitoring and compressive quality of anesthesiologist, because enough blood perfusion for vital organs must be guaranteed throughout the procedure. And it has limited effect and causes high risks [38]. Pre-ligation of internal iliac artery or abdominal artery through abdominal incision is seldom used to control blood loss in clinical, because it causes too much injury and high frequency of postoperative complications [1]. Embolization of bilateral internal iliac arteries and tumor arteries via femoral artery puncture can reduce blood loss greatly and improve surgical safety. However, this method is expensive and time-consuming and may increase the incidence of complications such as lower limb ischemic injury and local ischemic pain. Aortic occlusion with an inflated balloon is deemed to be an effective method for controlling blood loss, which significantly reduces blood loss, eases operation, and offers more time for surgeons to perform. Compared with preoperative iliac arterial or tumor blood supply embolization, balloon occlusion of the abdominal aorta is less complex and safer and is less expensive.

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