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CLINICAL CASE SERIES

Therapeutic Strategy and Outcome of Spine Tumors in Pregnancy

A Report of 21 Cases and Literature Review

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Study Design. A retrospective study was performed.

Objective. To illustrate the characteristics of spine tumors during pregnancy and obtain better insight into therapeutic strategies of such tumors by analyzing 21 cases treated in Changzheng Hospital and reviewing previous reports in the literature.

Summary of Background Data. The concurrence of spine tumors and pregnancy is relatively rare. There are controversies over the treatment options for this disease, which increase the difficulty of the clinical treatment.

Methods. Between 2002 and 2013, 21 pregnant patients were identified with spine tumors. Clinical data including symptoms, signs, treatment options, and obstetrical and neonatal outcomes were recorded and preserved. Clinical data and treatment efficacy were analyzed *via* medical record review.

Results. The median age of the 21 patients was 28.87 years (interquartile range, 6.00 yr). Tumor types in this series were giant cell tumor (5 cases), hemangioma (5 cases), schwannoma (4 cases), eosinophilic granuloma (2 cases), neurofibroma (1 case), multiple myeloma (1 case), and with metastatic tumor (3 cases). Two patients underwent spine surgery during pregnancy and 8 patients accepted tumor resection immediately after delivery. Pregnancy termination occurred in 5 patients, whereas the rest of the patients smoothly gave birth to healthy babies including 3 premature infants. Two patients died and 2 patients experienced local recurrence during follow-up.

Conclusion. With close observation, it was found that most of pregnant patients with benign spine tumors could postpone surgery after delivery. Surgical treatment should be adopted during pregnancy when patients are with highly malignant tumor or experience a sharp deterioration and the guard of it is safer than radiotherapy and chemotherapy during pregnancy.

Key words: spine tumors, pregnancy, surgery, therapeutic strategy, outcome.

Level of Evidence: 4

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The concurrence of tumor and pregnancy is a relative rare problem, occurring in about 1 in 1000 to 2000 pregnancies.[1] The most frequently encountered tumor types were breast cancer, hematological malignancies, and dermatological malignancies.[2] With the increase of tumor incidence and delayed fertility in females, the incidence of tumor during pregnancy increased significantly.[2] Therefore, information of the consequences of different treatment options in pregnancy is increasingly important.

Pregnancy-related spine tumor (PRST), which resulted from pregnancy-related breast cancer,[3] is thought to be the spine tumor diagnosed during pregnancy or within a year after delivery. Because of its low incidence, treatment recommendations are guided by case reports and small series of patients who underwent surgery for all spinal diseases during pregnancy.[4] It follows, then, the treatment of PRST still poses diagnostic and therapeutic challenges to the clinicians with regard to maternal and fetal wellbeing.

Here, we tried to illustrate the therapeutic strategies for PRST by retrospectively reviewing 21 consecutive patients with PRST who were treated in our institute from 2002 to 2013. To the best of our knowledge, this report represents the largest series focused on surgical treatment for PRST.

MATERIALS AND METHODS

A retrospective study was performed for patients with PRST who were treated at the spine tumor center of Changzheng Hospital (Shanghai, China) between 2002 and 2013. As a high-volume spine tumor center, Changzheng Hospital received and treated 3724 patients with spine tumors, of

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which 21 patients were diagnosed with PRST. Permission from the hospital ethics committee was obtained before commencing this study, and an informed consent was required from all patients or their legal guardians.

Because magnetic resonance imaging (MRI) has no obvious harm on fetation, it was the first choice to evaluate the spine lesion of pregnant patients with symptoms. Although radiographs and computed tomographic (CT) scans have great value for diagnosing spinal tumor, they were carefully selected in our series for fear of possible harm of pregnancy.

All the patients accepted treatment in Changzheng Hospital. Our principle of selecting treatment protocol was that symptomatic treatment and close surveillance during pregnancy were the first considered choice for those with indolent benign tumors and inapparent neurological deficit, and surgical resection was carried out within a year after delivery. However surgical resection would be adopted as soon as possible when a highly malignant tumor was confirmed or patients experienced a sharp deterioration. In the process of treatment, patients' clinical symptoms, gestational stages, and wishes were fully considered; meanwhile the final schemes were confirmed with help of obstetric and oncology experts.

The tumor types were confirmed by pathology in all patients. Preoperative neurological status was classified according to the Frankel score. Surgical strategy was decided for each patient according to Weinstein-Boriani-Biagini systems. Surgical procedures were performed by posterior approach, anterior approach, or a combination.

Benign tumors are routinely followed with MRI every 6 months for 2 years and then annually. For malignant tumors, MRI should be done every 3 months for 2 years, then every 6 months for the next 2 years, and then annually. Follow-up data were obtained from office visits and telephone interviews. In addition, neural function was re-evaluated 6 months after surgery according to the Frankel grading system.

RESULTS

Demographic Features

In total, 21 patients with PRST underwent surgical treatment in our spine tumor center. A summary of all variables is provided in Table 1. The median age at diagnosis was 28.87 years (interquartile range, 6.00 yr). Three patients (14.3%) were diagnosed in the first trimester, 10 (47.6%) patients presented in the second trimester, and 8 (38.1%) in the third trimester.

The distribution of tumor types was as follows: giant cell tumor (n = 5, 23.8%), hemangioma (n = 5, 23.8%), schwannoma (n = 4, 23.8%), eosinophilic granuloma (n = 2, 9.5%), neurofibroma (n = 1, 4.8%), multiple myeloma (n = 1, 4.8%), and spine metastases from either primary lung cancer (n = 1, 4.8%), cervical cancer (n = 1, 4.8%), or abdominal wall fibrosarcoma (n = 1, 4.8%).

Diagnostic and Therapeutic Approach

MRI was performed for all 21 cases. Nine patients had lesions in the thoracic spine, 6 in the lumbar spine, 5 in the cervical spine, and 1 in sacral spine. Six patients had lesions at multiple levels of the spine. In 5 cases, the lesions were located only in the intraspinal areas and neurological compression was caused by intraspinal soft-tumor masses. In the remaining 16 cases, the lesions located in the vertebrae, leading to the bone destruction, or even extended into the spinal canal. Neurological compression was caused by a combination of bony compression and epidural soft-tumor masses.

Of the 21 cases analyzed, 2 patients (no. 4, malignant giant cell tumor and no. 16, schwannoma) had already been subjected to incomplete tumor resection at another institution and 3 patients had a history of cancer (no. 5, lung cancer spine metastases; no. 19, fibrosarcoma; and no. 21, cervical cancer spine metastases). In the remaining 16 patients, we did not know the pathology of their tumors. Four hemangiomas were confirmed by typical imaging findings. On the premise that we had communicated the importance of biopsies, 2 patients (no. 9, eosinophilic granuloma and no. 17, hemangioma) underwent percutaneous CT-guided trocar biopsy with adequate antepartum protection of fetus. The other 10 patients refused needle biopsy and preferred intraoperative fast pathological examination and postoperative immunohistochemical staining for fear of possible fetal congenital anomaly or nerve damage.

Of the 11 patients with definite pathological diagnosis, 4 were advised surgical resection because of malignant tumor type (no. 4, recurrent malignant giant cell tumor; no. 5, lung cancer spine metastases; no. 19, fibrosarcoma; and no. 21, cervical cancer spine metastases). However, 1 patient (no. 5) chose to be treated with meperidine and underwent the radiotherapy after delivery. Six months later, a pathological fracture occurred in the L3 and the spine surgery was performed. Other 7 patients, along with 10 patients who did not have a definite pathological diagnosis, were closely monitored and re-examined by MRI every 3 months or when clinical deterioration happened suddenly. Ten patients were treated with acetaminophen or meperidine during pregnancy for their focal pain. Finally, they all responded well to either medication and postponed the surgical treatment until delivery.

Although this process was monitored closely, 3 patients presented with paralysis during pregnancy because of rapid tumor growth. An obvious tumor growth during pregnancy can also be seen on MR image (no. 20 malignant giant cell tumor) (Figure 1). Two of them (no. 10, neurofibroma and no. 20, malignant giant cell tumor) chose to undergo immediate surgery (within 3 d) during pregnancy and the remaining one (no. 12, hemangioma) did not undergo decompression until postpartum.

Among the other 14 patients who did not have a definite pathological diagnosis, 7 patients (no. 1, schwannoma; no. 3, giant cell tumor; no. 6, hemangioma; nos. 11–13, hemangioma; and no. 18, schwannoma) had the immediate surgery within 1 day after delivery for experiencing sudden deteriorated symptoms during delivery (n = 4) or performing preterm making a compromise by further surgical treatment (n = 3). The other 7 patients underwent elective surgery within 1 year after delivery.

TABLE 1. Demographic Features, Treatment Characteristics, Fetal, and Maternal Outcome of the

Case	Symptoms	Diagnosis	Age	Gestational Age	Physical Examination	Treatment During Delivery	Level
1	Numbness; pain*	Schwannoma	22	The third trimester	Fg D (LLs)	None	T9–T10
2	Pain	Giant cell tumor	30	The third trimester	Fg C (LLs)	Meperidine	T12
3	Weakness; pain*	Giant cell tumor	26	The third trimester	Fg D (LLs)	Meperidine	L1
4	Swelling; weakness	Recurrent malignant giant cell tumor	32	The first trimester	Fg D (ULs and LLs)	Meperidine	C2
5	Numbness; pain*	Lung cancer spine metastases	27	The third trimester	Fg D (ULs)	Meperidine	L3–L5
6	Pain*	Hemangioma	28	The second trimester	Fg B (LLs)	Acetaminophen	T3
7	Swelling; weakness	Eosinophilic granuloma	23	The second trimester	Fg C (LLs)	Acetaminophen	C4
8	Pain	Giant cell tumor	24	The third trimester	Fg C (LLs)	None	L5
9	Pain	Eosinophilic granuloma	32	The first trimester	Fg D (LLs)	Surgery	T5
10	Paralysis; pain	Neurofibroma	26	The third trimester	Fg B (ULs and LLs)	Surgery	C3–C6
11	Weakness; pain	Hemangioma	29	The second trimester	Fg B (LLs)	Acetaminophen	T7
12	Paralysis; pain	Hemangioma	28	The second trimester	Fg A (LLs)	Acetaminophen	T6
13	Pain*	Hemangioma	30	The second trimester	Fg C (LLs)	Meperidine	L1, L3
14	Pain	Multiple myeloma	38	The second trimester	Fg D (LLs)	None	T7
15	Pain	Schwannoma	36	The second trimester	Fg D (LLs)	Meperidine	L1
16	Weakness; pain	Recurrent schwannoma	29	The third trimester	Fg C (LLs)	None	S1
17	Pain	Hemangioma	32	The third trimester	Fg D (LLs)	Meperidine	T4
18	Weakness; numbness	Schwannoma	22	The second trimester	Fg B (LLs)	None	C3–C4
19	Pain	Metastatic fibrosarcoma	35	The 1st trimester	Fg D (LLs)	Surgery	L2
20	Right hemiplegia; pain	Malignant giant cell tumor	26	The second trimester	Fg A (LLs)	Surgery	C3, C4
21	Weakness; pain	Cervical cancer spine metastases	29	The second trimester	Fg C (LLs)	Surgery	T8

**Symptoms deteriorated after delivery.*

Fg indicates Frankel grading; IFPE, intraoperative fast pathological examination; PTB, percutaneous trocar biopsy under CT guidance; US, for urgent surgery; TYC, delivery; TA, therapeutic abortion; LL, lower limbs; UL, upper limbs; CT, computed tomography.

Our Cases						
Preoperative Biopsy	**Treatment After Delivery**	**Surgical Position**	**Blood Loss**	**Operation Method**	**Fetal Outcome**	**Maternal Outcome Till the Last Follow-up**
IFPE	Surgery	Posterior approach	600 mL	CTR	VD	Alive; well 123 mo
IFPE	Surgery	Posterior approach	2300 mL	PS	CD	Alive; well 84 mo
IFPE	Surgery	Posterior approach	3000 mL	PS	CD	Alive; well 81 mo
Surgery history	Surgery	Combined approach	2100 mL	PS	Preoperative TA	Died at 42 mo (metastasis to lung)
A history of cancer	Surgery	Posterior approach	3000 mL	PS	VD	Died at 28 mo
TYC	Surgery	Posterior approach	1200 mL	CTR	CD	Alive; well 63 mo
IFPE	Surgery	Combined approach	600 mL	CTR	CD	Alive; well 58 mo (tumor metastases and underwent radiotherapy
IFPE	Surgery	Combined approach	2400 mL	PS	CD	Alive; well 58 mo
PTB	None	Posterior approach	1900 mL	CTR	Preoperative TA	Alive; well 55 mo
IFPE	Reoperation	Posterior approach	1200 mL	CTR	CD	Alive; tumor recurrence; underwent surgery again; now well 50 mo
TYC	Surgery	Posterior approach	2000 mL	CTR	CD (preterm)	Alive; well 46 mo
TYC	Surgery	Posterior approach	2000 mL	CTR	CD (preterm)	Alive; well 43 mo
TYC	Surgery	Posterior approach	1700 mL	CTR	VD	Alive; well 32 mo
IFPE	Surgery	Posterior approach	1000 mL	PS	VD	Alive; well 29 mo
IFPE	Surgery	Posterior approach	50 mL	CTR	CD	Alive; well 25 mo
Surgery history	Surgery	Posterior approach	400 mL	CTR	CD	Alive; well 24 mo
PTB	Surgery	Posterior approach	1600 mL	ES	CD	Alive; well 24 mo
IFPE	Surgery	Posterior approach	500 mL	CTR	CD (preterm)	Alive; well 24 mo
A history of cancer	None	Posterior approach	2800 mL	PS	Preoperative TA	Alive; tumor recurrence; underwent surgery again; now well 19 mo.
IFPE	Radiotherapy	Combined approach	1500 mL	PS	Postoperative TA	Alive; well 16 mo
A history of cancer	None	Posterior approach		PS	Preoperative TA	Alive; well 14 mo

typical imaging confirmed; CTR, complete tumor resection; PS, piecemeal spondylectomy; ES, en bloc *spondylectomy; VD, vaginal delivery; CD, cesarean*

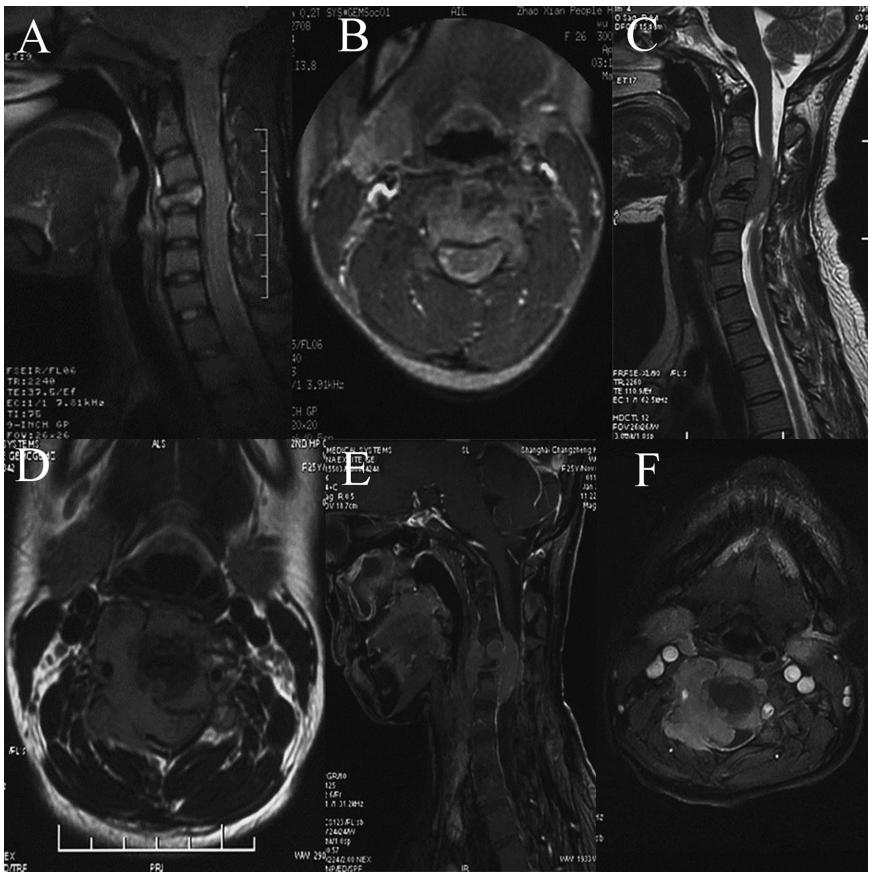

Figure 1. The process of tumor growth after pregnancy (no. 20): MRI of the sagittal (**A**) and axial (**B**) plane before pregnancy showing a vertebral compression fracture of C4. MRI of the sagittal (**C**) and axial (**D**) plane of T2; contrast-enhanced MRI of the sagittal (**E**) and axial (**F**) plane during pregnancy revealing a vertebral compression fracture of C4 and the compression of the cervical spinal cord by a large mass located on the right side of segments C3–C5 in the epidural regions. MRI indicates magnetic resonance imaging.

Of the 21 cases analyzed, 5 intraspinal tumors (no. 1, schwannoma; no. 10, neurofibroma; nos. 15, 16, schwannoma; and no. 18, schwannoma) underwent posterior surgical decompression and complete tumor resection. Complete tumor resection with titanium mesh cage placements has been used in 4 vertebral hemangiomas (no. 6, 11–13) and 2 (no. 7, 9) eosinophilic granulomas. Total spondylectomy *via* an *en bloc* or piecemeal methods suspected for aggressive and malignant lesions were used *via* a posterior approach in 7 cases and combined approaches in 3 cases.

Follow-up for Fetal and Maternal Outcome

In 5 patients, termination of pregnancy was advised because of diagnosis in early pregnancy (n = 2, GA of 5 and 6 wk), cervical cancer combined with spine metastases (n = 1), or hormone-related rapid clinical deterioration (n = 2). The latter was decided by immunohistochemical staining for estrogen receptors (ERs) and progesterone receptors. If the results were positive for ERs and progesterone receptors, we may suppose pregnancy may be implicated with the progression of tumor. In 12 (57%) patients, elective caesarean section was performed and 4 (19%) patients had a vaginal delivery. Three patients (nos. 11, 12, hemangioma and no. 18, schwannoma) performed preterm (GA of 33, 34, and 34 wk) to start treatment immediately after delivery and elective caesarean section was performed for them. All other patients gave birth at term. Two patients (2/12) with cesarean delivery and 3 patients (3/4) with vaginal delivery developed aggravated neurological deficit just after delivery.

All patients were followed for a minimum of 14 months, with a median follow-up period of 38.0 months (interquartile range, 32.5 mo). Two patients died during follow-up because of rapid tumor growth of lung cancer (no. 5) causing systemic complications and malignant giant cell tumor (no. 4) metastasizing to lung, both of whom treated with a piecemeal spondylectomy. One patient with eosinophilic granuloma (no. 7) experienced tumor metastasis to bilateral ilium and underwent radiotherapy; 1 neurofibroma (no. 10) treated with a complete tumor resection and 1 metastatic fibrosarcoma treated with a piecemeal spondylectomy (no. 19) experienced local recurrence and both of them underwent a complete tumor resection again. They are all stable after the second treatment. The remaining 16 patients were well with no evidence of tumor recurrence on MR image at the last follow-up.

For all patients, their pain was mostly absent and limb weakness had improved to at least 1 level by their 6-month follow-up visit. At the last follow-up, 1 patient (no. 12), who experienced paralysis for 4 months, could walk with the support of a stick and the other 18 patients who were still alive could walk.

Clinical information regarding the children was registered at birth and in the immediate neonatal period, and no fetal congenital anomaly was found and none of the premature infants experienced respiratory problems. During the follow-up, no problems directly related to the aforementioned

treatment were noted in any of children including the patient who underwent surgical treatment during pregnancy.

DISCUSSION

Characteristics of PRST

PRST was first recognized in the 1950s[5] and the mechanism of pregnancy affecting primary spine tumors is still scant. Many authors have stated that hormonal changes during pregnancy can influence tumor growth and trigger rapid changes in neurological symptoms.[6–10] For the majority of PRSTs, the tumors may exist before pregnancy and convert to be symptomatic ones during pregnancy. In this report, 18 patients presented with symptoms initially and 3 patients had recurrences from primary existing tumors during pregnancy. We found ERs and progesterone receptors in 2 of our patients (nos. 19, 20), which was also demonstrated by other studies that may result in a possible hormonal influence on the growth.[9,11,12] Moreover, increases in the levels of growth factors and angiogenic factors during pregnancy are also reported to influence the rate of growth of tumors.[13] With regard to vertebral hemangiomas, pregnancy can increase the growth of hemangioma through hormonal changes (increase the venous distensibility due to the endothelial growth-promoting effect) and hemodynamic changes (redistribution and increased blood flow volume through the vertebral venous plexus secondary to the *gravid* uterus compressing the vena cava).[8]

In this series, we analyzed the clinical data of 21 patients with spine tumors diagnosed during pregnancy. The most common tumor types of pregnancy-related tumor reported in the literature are breast cancer, hematological malignancies, and dermatological malignancies,[2] but we found giant cell tumor, hemangioma, and schwannoma were the most frequent tumor types of PRST. Characteristically, those tumors often occur in young adults between their second and fourth decades,[5] which is thought to be reproductive age for females.

The most common clinical symptoms of PRST are limbs numbness and progressive neurological deficit. For vertebral PRST, expansile enlargement of the vertebral bodies, posterior elements, or a direct invasion of the extradural space by subperiosteal tumor growth[7] can result in local pain, swelling, even leading to progressive neurological deficit.

Therapeutic Strategy

A multidisciplinary discussion among orthopedists, obstetricians, and anesthetists should be made to develop the therapeutic strategy according to the tumor biology, tumor stage, degree of spinal cord compression, gestational stage, potential risks to the fetus from various treatment modalities, and the patient's and her family's wishes. Nowadays, 3 main scenarios for pregnancy in cancer exist[14]: first, the ideal scenario when proposed treatment is possible to adhere to the standard for nonpregnant patients; second, when immediate treatment is needed, which puts the pregnancy at risk, and termination of pregnancy followed by treatment; and third, the diagnoses of cancer in the later stages of pregnancy, awaiting or expediting delivery and then treating the cancer.

Fetal exposure and damage can occur during staging examinations.[15] Toxic radiation effects, such as mental retardation and organ malformations, will only be induced when fetal exposure exceeds the threshold dose of 0.1 to 0.2 Gy,[16] and the majority of diagnostic procedures do not involve fetal exposure more than 0.05 Gy.[15] Thus, radiographical examinations are possible, but should be done only when the results will change clinical management. Contrast-enhanced MRI focused on the affected spinal segment should also be performed to monitor the extensiveness of the tumor and spinal canal involvement. However, gadolinium-based MRI contrast agents have been reported to pass through the placental barrier, which results in the potentially toxic gadolinium ion dislocating from its chelate molecule into the amniotic fluid and enter fetal circulation.[17] Gadobenate dimeglumine, approved by the European Medicines Agency and US Food and Drug Administration, was used for pregnant patients in our study and no congenital anomaly had occurred in the neonates.[18] In our study, no problem directly related to ionizing radiation was noted in children whose mother underwent percutaneous CT-guided trocar biopsy during pregnancy. However, it is contraindicated for lumbar and sacral tumors for impossible protection of fetus.[16] Thus, in our opinion, percutaneous CT-guided trocar biopsy for cervical and thoracic tumors is relative safe with adequate protection of fetus in pregnancy. Moreover, although we have not performed percutaneous MRI-guided biopsy in this study, we also suppose pregnancy would be a perfect indication for such a procedure.

Conservative Treatment

Conservative treatment was considered to be the first choice for pregnant patients with adolescent benign tumors,[4,19] and pain control was extremely important for patients with PRST. Nonsteroidal anti-inflammatory drugs or muscle relaxants are not recommended for patients during pregnancy due to their potential for congenital anomalies.[20] Our study found that focal pain of pregnant patients could be safely controlled by acetaminophen or meperidine and no congenital anomaly had occurred. In our series and previous literature reports,[6,19,21,22] although the resection of most PRSTs, except the malignancies, can be delayed until postpartum, sharp deterioration of signs and symptoms can be also found during the period of conservative treatment.[7,23] Therefore, close surveillance, mainly monitoring and reexamination by MRI every 3 months, is essential for conservative treatment, and surgical treatment could be adopted at this point with full consideration of gestational weeks.

Radiotherapy and Chemotherapy

Radiotherapy can be used to treat spine tumors, but adverse events occurred at all phases of gestation. Luis *et al*[24] recorded that 13 of 109 neonates had adverse long-term fetal outcomes, including perinatal deaths and neurological disorders. Thus, radiotherapy is not recommended for patients during pregnancy, especially for those with tumor located in lumbar spine and sacrum, unless the uterus can be sure to be screened from dangerous exposure during radiotherapy.[16]

Although most of spinal tumors, such as giant cell tumor, hemangioma, and schwannoma, are not sensitive to chemotherapy, it can effectively control spine metastases and hematological malignancy.[3,25,26] There are great controversies about the use of chemotherapy in pregnancy because chemotherapy drugs might be able to cross the placenta and result in congenital malformations in the period of organogenesis (the first trimester).[27,28] Moreover, they can also impair fetal growth and functional development in the second and third trimesters.[28,29] In the opinion of Amant *et al*,[3] clinicians should not put maternal prognosis at risk to limit or reduce unproven fetal damage; and standard regimens could be used in pregnancy. However, Van *et al*[2] found that prenatal exposing to cytotoxic treatment had increased the proportion of preterm labor and small-for-gestational-age children. Thus, we suppose the administration of chemotherapy in pregnancy is only advised by the deteriorated maternal situation.

Parturition and Timing of Spine Surgery

By reviewing the literature[4,7,30] and our personal experience, the fetal outcomes of patients who performed preterm were good. Therefore, we suppose, if patients at 32 to 36 weeks of gestation or later experienced sudden deterioration and ought to start further treatment immediately, the induction of delivery or cesarean section can be performed at the time. Patients may also experience sudden deterioration during parturition, especially in patients with vaginal delivery. Dham *et al*[31] reported that it took several days for hormones to reach *pregravid* levels after parturition, and also proposed an increased growth potential of tumors in both pregnancy and the initial postpartum period. In our opinion, the pressure change of thoracic or abdominal cavity secondary to parturition may also contribute to it, because none of patients with cervical spine tumor in our study had experienced that. Therefore, the elective caesarean section is a relative safe delivery mode for PRST due to its lower incidence of this condition. In this case, urgent spine surgery should be prepared for possible rapidly progressing motor weakness during parturition.

Therapeutic Abortion

The patient and her family should be informed about the possible congenital anomaly related to different treatment options and the relationship between the tumor growth and pregnancy,[30] but the decision to continue or end the pregnancy is a personal one.

Prepartum Spine Surgery

Progressive neurological deficit due to rapid tumor growth during pregnancy is hard to recover even after postpartum surgery. Moreover, *gravida* and infant might experience death when highly malignant tumor is not timely treated in pregnancy.[32] Prepartum surgery is a choice for patients who encounter malignant tumor or sudden deterioration, although it may lead to preterm labor or fetal damage.[26] A study that estimates the fetal deaths during surgery in the first trimester suggests that the risks are 8% to 11% on the basis of a few small reports, with no specific indication or type of surgery.[33] Therefore, sufficient preparation is of great importance for prepartum surgery. Anesthetic agents, antibiotics, and analgesics should be selected in consideration of the safety for the fetus (Food and Drug Administration categories A and B).[14,34–36] Sufficient analgesia is needed to avoid preterm onset of labor that may also be provoked by pain and fetal heart-rate monitoring is required to detect fetal condition during surgery. Furthermore, decreased placental perfusion secondary to the compression of vena cava and *gravid* uterus in the prone position is also a mechanical problem,[14] so the prone position cushions should be used during operation. In addition, thromboprophylaxis with low-molecular-weight heparin is indicated because pregnancy is an additional risk factor for thrombosis. At last, in our cases, we did not use systemic steroids or mannitol for fear of suppression of the fetal pituitary-adrenal axis or dehydrating the fetus,[37] and these limitations should be told to patient and her family that it may interfere with the recovery of impaired neurological function.

CONCLUSION

This report emphasizes the main roles of clinical evaluation and therapeutic strategies for spine tumor in pregnancy. With close observation, most of pregnant patients with spine tumors could postpone the spine surgery after delivery. Surgical treatment should be adopted during pregnancy when patients are with highly malignant tumor or experience a sharp deterioration and the guard of it is safer than radiotherapy and chemotherapy during pregnancy.

➢ Key Points

- ❑ The concurrence of spine tumors and pregnancy is relatively rare. The optimal treatment options for this disease have been controversial and pose a challenge for the clinicians with regard to maternal and fetal wellbeing.
- ❑ We retrospectively reviewed 21 consecutive patients with PRST treated surgically in our institute from 2002 to 2013, illustrating the therapeutic strategies as well as the fetal and maternal outcome. To the best of our knowledge, this report represents the largest series.
- ❑ With close observation, most of pregnant patients with benign spine tumors could postpone surgery after delivery.
- ❑ Surgical treatment should be adopted during pregnancy when patients are with highly malignant tumor or experience a sharp deterioration and the guard of it is safer than radiotherapy and chemotherapy during pregnancy.

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Tong Meng, Huabin Yin, and Zhenxi Li contributed equally to this work, and all the 3 authors can be regarded as first authors.

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