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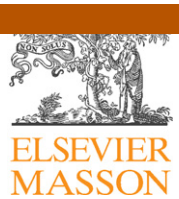

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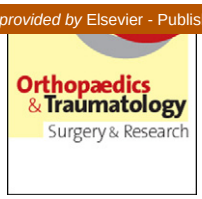

ORIGINAL ARTICLE

Pelvic chondrosarcomas: Surgical treatment options

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KEYWORDS
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Pelvis;
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Summary
Introduction: Chondrosarcoma (CS) is a primary malignant bone tumor with cartilaginous differentiation. The only available treatment is carcinological surgical resection since the usual adjuvant treatments are ineffective. The pelvic location creates specific technical difficulties both for exeresis and reconstruction. Our objective was to evaluate the carcinological and functional outcomes of inter-ilioabdominal amputation and conservative surgery.
Materials and methods: We retrospectively studied 59 cases of pelvis chondrosarcoma managed in our department between 1968 and 2003. Demographic, anatomopathological, surgical and survival data were analyzed. Survival was estimated by the Kaplan-Meier curves and the cumulative incidence method. Multivariate analysis was used to identify all possible independent prognostic variables.
Results: There were 33 men and 26 women, with an average age of 48 years. The average follow-up duration was 94 months. Eleven patients had a grade 1 chondrosarcoma, 36 a grade 2 chondrosarcoma, five were grade 3, and seven were dedifferentiated chondrosarcoma. Eleven patients underwent an inter-ilioabdominal disarticulation, and 48 had a more conservative surgery. Resection margins proved healthy in 46 patients (78%). Eighteen patients (31%) had a local recurrence, and 12 (20%) had metastases. At last follow-up, 30 patients (51%) were still alive without any sign of recurrence. Twenty-three patients (39%) died from the disease. Multivariate analysis showed that margin invasion was associated with a definitely increased local recurrence rate. A high tumoral grade was correlated with a greater risk of metastases occurrence. These two last factors (margin status and tumor grade) as well as acetabulum involvement were correlated with a reduced survival rate.

Function was better among patients treated by conservative surgery, and among them, even better when the peri-acetabular area remained intact.

Our study confirmed that resection margins quality is a major prognostic factor both for local control and for survival. On the other hand, local recurrence is an adverse survival prognosis factor and is itself correlated with resection margins quality.

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Peri-acetabular chondrosarcoma location (in zone 2) appears to be a poor oncological prognosis factor since, in this location, obtaining healthy margins appears particularly difficult.

Compared to resection, inter-ilioabdominal amputation did not prove its superiority concerning resection margins quality or survival. However, resection guaranteed a better functional outcome.

Conclusion. — Chondrosarcoma of the pelvic girdle remains of worse prognosis than peripheral bones chondrosarcoma since the critical prognosis factor is the resection margins quality. This location, and especially the peri-acetabular zone, poses difficult specific technical problems when conservative surgery is selected. Various imaging techniques should help better envision tumor resection extent. Inter-ilioabdominal amputation should only be resorted to in non-metastatic patients, when the tumor does not seem to be removable with sufficient healthy margins guarantee, or when local conditions make it impossible to hope for a good quality reconstruction.

Level of Evidence. — Level IV; therapeutic retrospective study.

Introduction

Chondrosarcoma (CS) is a malignant skeletal tumor with cartilaginous differentiation. In terms of incidence, it represents the second most frequent bone tumor in adults [1], and is preferentially located in the pelvis in 22 to 39% of cases [2—7]. CSs of the pelvic girdle remain asymptomatic in the long-term and may thus be large at the time of diagnosis.

From a therapeutic viewpoint, CS is individualized from other primary skeletal tumors as it is radioresistant and chemoresistant: its only treatment is carcinological surgical exeresis. However, depth in the pelvis, tumor size and its connections with local articular, nervous, vascular and visceral structures very often make carcinological exeresis difficult and require complex reconstructions [8—12].

The objective of this work is to evaluate the carcinological and functional results of different surgical treatments of CS of the pelvic girdle.

Materials and methods

We report data from a retrospective, monocentric study in a series of 59 patients with CS of the pelvis and treated surgically by the Orthopaedics Service of Cochin Hospital between 1968 and 2003. Patients treated initially in another establishment were not included.

In all cases, the diagnosis of CS was confirmed histologically by a referred pathologist specialized in the diagnosis of tumors of the locomotor apparatus. The following clinical data were analyzed: sex, age, initial clinical picture, duration of symptoms at the time of diagnosis. Tumor location was studied on radiographs as well as by scanner and magnetic resonance imaging when they were available. The topographical characteristics of the tumor were expressed according to the Muskuloskeletal Tumor Society classification [10,13]. Macroscopic data, i.e., tumor size defined by its largest diameter, and microscopic findings, i.e. grade according to O'Neal and Ackerman [14], were collected. Resection margins were analyzed according to the classification of Enneking et al. [15]. Type of surgical intervention, local recurrence, metastases, and patient outcome were studied. Function was evaluated by walking, and pain graded according to the 30-point score of the Musculoskeletal Tumor Society [16].

Follow-up was calculated from the intervention data at Cochin Hospital until the day of death or the last follow-up. Survival was estimated by Kaplan-Meier curves and the cumulated incidence method in the presence of events competing with the event of interest.

Cox's proportional model was used to estimate the effect (hazard ratio or relationship of instant risks) of different variables on the events considered. Multivariate analysis served to identify a set of variables independently prognostic of the events. The analyses were performed with the R 2.5.1 statistical analysis program; all tests were bilateral and significant from a threshold of 0.05.

Results

Epidemiology

Thirty-three men and 26 women, with an average age of 48 years at the time of diagnosis (23 to 78 years) were managed for CS of the pelvic girdle. Average follow-up was 94 months (3—311 months). The patients were followed for a minimum of four years or until their death.

Histology

Fifty-two patients had a biopsy before exeresis. In seven cases, the histological diagnosis was confirmed by the study of exeresis pieces without preliminary biopsy.

Forty-seven patients (80%) had a primary CS, and 12 (20%) had a secondary CS with a preexistent benign tumor (Table 1).

Grade 2 CSs were most frequent ($n = 36$). This series had seven dedifferentiated CS.

Topography

Fourteen patients (24%) had a zone 1 (iliac) tumor, including four with sacral invasion; 42 patients (71%) had a zone

Table 1 Epidemiological and histological characteristics of our series.

	n (%)
Men	33 (56)
Women	26 (44)
Tumor grade [20]	
1	11 (19)
2	36 (61)
3	5 (8)
Dedifferentiated	7 (12)
Tumor size	
≤ 10 cm	35 (59)
> 10 cm	24 (41)
Primary tumors	47 (80)
Secondary tumors	12 (20)
Solitary exostosis	2
Exostosis disease	7
Multiple	
Ollier's disease	2
Paget's disease	1

2 (acetabular) lesion, and three patients (5%) had zone 3 (ischiopubic) lesion.

Clinical data

The average duration of symptoms before the diagnosis was 14.5 months. Pain was the most frequent symptom ($n = 45$). Eight patients consulted because of palpable tumefaction. The other patients consulted because of abnormal radiological imaging.

One patient had a pulmonary metastasis at the time of diagnosis.

Treatment

Eleven inter-ilioabdominal disarticulations and 48 conservative interventions were performed. In three cases of dedifferentiated CS, chemotherapy was associated with surgery.

Zone 1 CS ($n = 14$)

Eleven patients underwent partial or total resection of the ilium. In two cases, exeresis included the sacrum. An amputation was undertaken because of major invasion of the sacral plexus.

Zone 2 CS ($n = 42$)

There were five isolated resections of the acetabulum.

Twenty patients had partial or total resection of the acetabulum associated with partial or total resection of the pubis or ischium.

Four partial or total resections of the acetabulum were undertaken in association with all or part of the ilium.

Three patients had resection of the acetabulum, ilium and ischium and/or the pubis.

Ten inter-ilioabdominal disarticulations were performed.

Zone 3 CS ($n = 3$)

All cases were treated by exeresis of all or part of the ischium and the pubis.

Resection margins

They were considered to be healthy in 46 cases (78%), marginal in two cases (3%) and contaminated in 11 cases (19%).

In the amputation group ($n = 11$), the margins were healthy in seven cases (63%), and contaminated in four cases (37%).

In the conservative treatment group ($n = 48$), the margins were healthy 39 times (81%), exeresis was marginal twice (5%), and the margins were contaminated seven times (14%).

Reconstruction

After resection of the iliac wing ($n = 13$), reconstruction was carried out in three cases, by autografts ($n = 2$) or allografts ($n = 1$).

After resection of all or part of the acetabulum ($n = 32$), reconstruction was conducted according to the following techniques:

- total hip prostheses, $n = 10$, with six Puget interventions (Fig. 1);
- saddle prostheses, $n = 8$;
- arthrodesis, $n = 7$, with three femoro-iliac arthrodesis, three femoro-obturator arthrodesis and one femorocotyloid arthrodesis;
- bone reconstructions of the cotyle, $n = 4$;
- neocotyles at the expense of the iliac wing, $n = 2$.

In one case, no reconstruction was undertaken: resection involved a non-weight-bearing zone of the posterior cotyle wall.

No reconstructions were carried out after isolated resection of the pubis ($n = 3$).

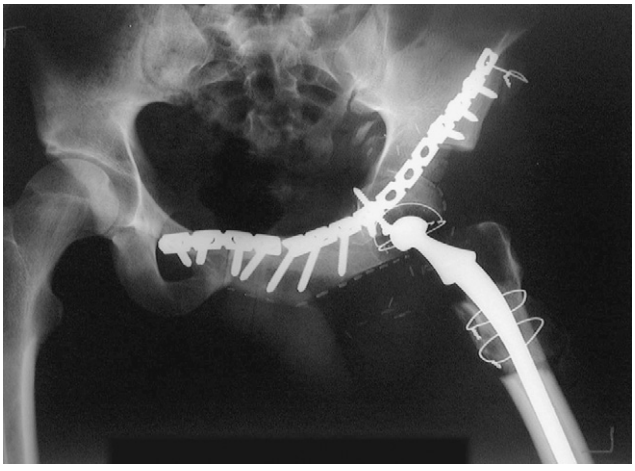

Figure 1 Reconstruction according to the Puget technique.

Carcinological results

Survival

Thirty patients (51%) were alive without signs of recurrence at last follow-up, with a survival average of 123 months (48 to 272 months).

Twenty-three patients (39%) died from the disease. Their average survival was 69 months (3 to 312 months).

Six patients (10%) died from another cause without known recurrence at the time of their death, within an average of 59 months (6 to 119 months).

Thus, the global survival rate was 90% (CI: 82—98%) at one year, 66% (CI: 55—80%) at five years, 52% (CI: 39—70%) at 10 years and 45% (CI: 32—64%) at 15 years (Fig. 2).

Multivariate analysis searched for risk factors of death. This analysis showed that invasive resection margins ($p = 0.00001$, RR = 7.28) (Fig. 3), high histological grade (3 or dedifferentiated) ($p = 0.0005$, RR = 4.57) (Fig. 4), and tumors invading the acetabulum ($p = 0.049$, RR = 3.24) were statistically pejorative factors for survival.

Local recurrence

Eighteen patients (31%) had a local recurrence within an average period of 37 months (5 to 230 months), associated in four cases (22%) with one or more metastases at the time of diagnosis (Table 2).

Among the 14 patients with a local recurrence without metastasis at the time of diagnosis, three (21%) had secondary metastases within an average of 27 months after the first recurrence (15 to 43 months).

Local recurrence was treated surgically in 12 cases: interilioabdominal disarticulation from diagnosis in one case, intralesional exeresis surgery in 11 cases, multiple surgeries in six cases (two to 11 revisions). Three patients had an interilioabdominal amputation afterwards. A patient with local recurrence and synchronous adrenal metastasis received chemotherapy (dedifferentiated CS).

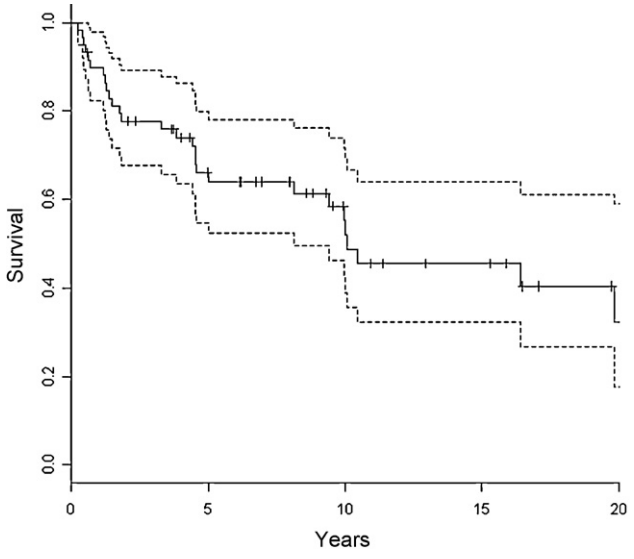

Figure 2 Kaplan-Meier analysis of global patient survival. The studied event was patient death in relation to the disease.

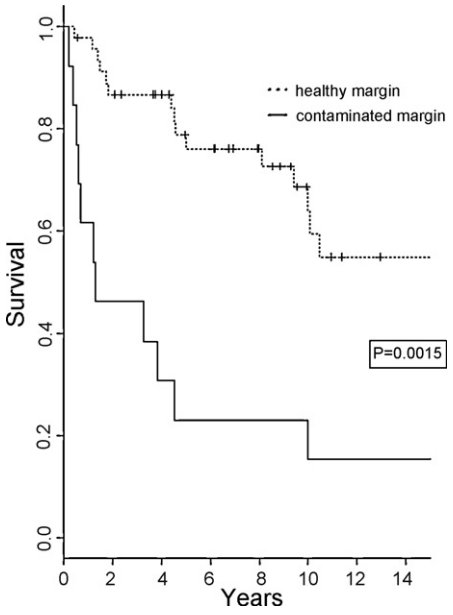

Figure 3 Comparison according to the Cox model of global patient survival as a function of resection margin quality.

A patient with local recurrence and synchronous pulmonary metastasis was treated by chemotherapy alone.

Five patients received no treatment.

All patients who had a local recurrence died within an average time period of 38 months (0—240 months) after the diagnosis of recurrence. Reoperated patients lived an average of 55 months (1—240 months), non-reoperated patients lived an average of 3.5 months (0—6 months), but among them, three had metastases at the time of local recurrence diagnosis.

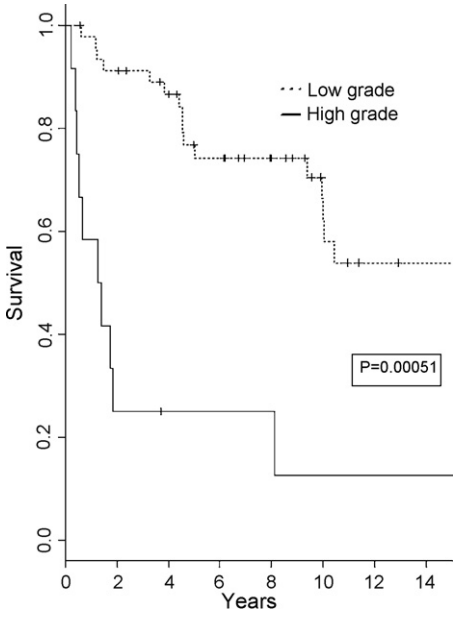

Figure 4 Comparison according to the Cox model of global patient survival as a function of histological tumor grade. Low grade: grades 1 and 2; high grade: grade 3 and dedifferentiated CS.

Table 2 Characteristics of local recurrences.

Local recurrences	
Cases/total	18 (31%)
Location	
Zone 1	3/14 (21%)
Zone 2	14/42 (33%)
Zone 3	1/3 (33%)
Margins	
Healthy	8/46 (17%)
Marginal	2/2 (100%)
Contaminated	8/11 (72%)
Initial CS grade	
1	2/11 (18%)
2	12/36 (33%)
Dedifferentiated	4/7 (57%)
Time period after initial intervention	37 months
Associated metastases	
Synchronous	4
Asynchronous	3
Treatment	
Surgery	12 (66%)
Chemotherapy	2 (11%)
None	5 (28%)
Delayed diagnosis — death	38 months

Table 3 Characteristics of metastases.

Metastases	
Cases/total	12
Postoperative occurrence	41 months
Without local recurrence	5/12 (42%)
With local recurrence	7/12 (58%)
Location	
Lungs	11
Liver	2
Adrenals	1
Initial CS grade	
2	7/36 (19%)
3	1/5 (20%)
Dedifferentiated	4/7 (57%)
CS topography	
Zone 2	11
Zone 3	1
Delayed diagnosis — death	8 months

Multivariate analysis objectively established that the risk of local recurrence was strongly correlated with invasion of the resection margins ($p = 0.001$). The probability of local recurrence at 10 years was 15% for patients with healthy resection margins, and was 54% for patients whose margins were contaminated (Fig. 5).

On the other hand, high histological grade (3 and dedifferentiated) was not a risk factor for local recurrence ($p = 0.3$), just like tumor location ($p = 0.28$) (Fig. 6).

Metastases

Twelve patients (20%) developed metastases, associated with local recurrence in seven cases (58%), synchronous in four, or secondary in three (Table 3).

The average time of occurrence was 41 months (3 to 189 months). Metastases were most frequently localized in the lungs ($n = 11$), associated in two cases with liver metastases. We observed a case of adrenal metastasis during the evolution of dedifferentiated CS.

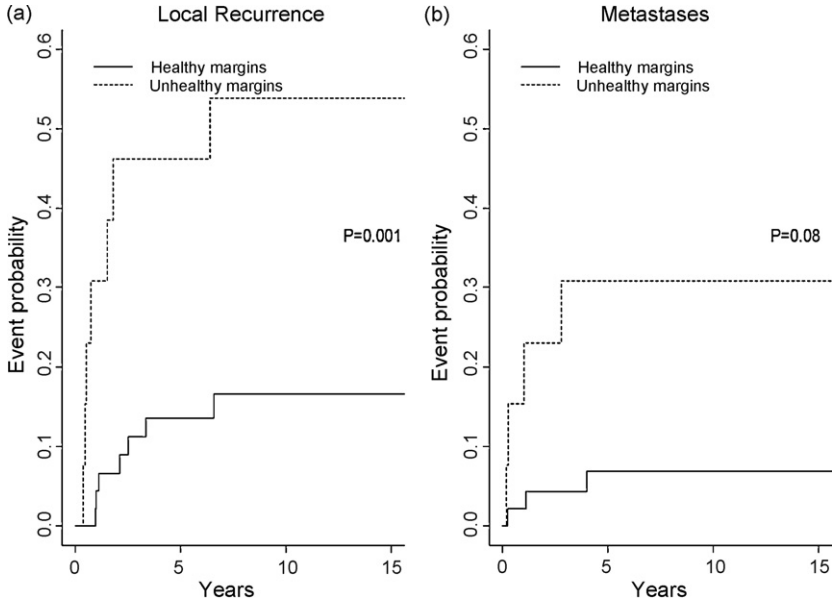

Figure 5 Analysis according to the cumulative incidence method of local recurrence risk (Fig. 5a) and metastasis (Fig. 5b) as a function of resection margin quality. a: event probability local recurrence metastases.

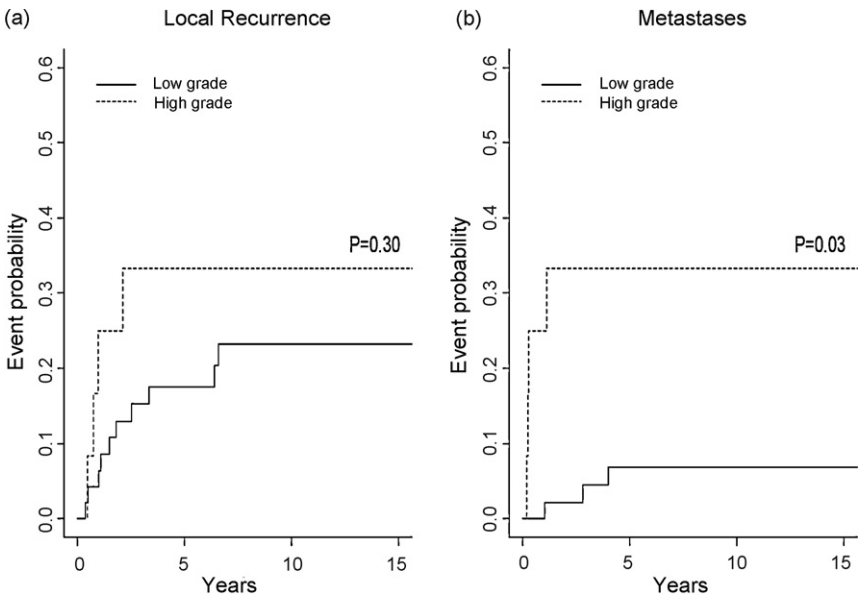

Figure 6 Analysis according to the cumulative incidence method of local recurrence risk (Fig. 6a) and metastasis (Fig. 6b) as a function of histological tumor grade. Low grade: grades 1 and 2; high grade: grade 3 and dedifferentiated CS.

Metastases complicated the evolution of seven grade 2 CS (19% of grade 2 CS), one grade 3 CS (20%) and four dedifferentiated CS (57%).

Two metastasectomies were performed: one pulmonary metastasis and one adrenal metastasis, responsible for perioperative patient death.

All patients died within an average time period of eight months (1 to 55 months) after the diagnosis of metastasis.

Multivariate analysis showed that high histological grade (3 or dedifferentiated) was correlated with a high risk of metastasis ($p = 0.03$) (Fig. 6). Tumor size and resection margin quality were not statistically significantly correlated with the occurrence of metastasis.

Functional results

The average score obtained was 18 out of 30 (5 to 28).

In amputated patients ($n = 3$), it was on average six points. These patients received Canadian prostheses, and one of them used it only inside his residence.

In patients treated by conservative surgery, the average score was 20 (14 to 28). Patients whose resection did not touch the acetabulum scored an average of 26 points (20 to 28), whereas those whose resection involved all or part of the cotyle had an average score of 16 points (14 to 21).

Complications

Forty complications occurred and are regrouped in Table 4.

The main complications were infectious in the amputation group, and mechanical in the conservative surgery group.

In addition, three perioperative deaths occurred after surgical revision for recurrences: a patient died during exeresis of an adrenal metastasis 22 months after his initial conservative treatment for dedifferentiated CS. Another patient died in the course of his fifth palliative revision (intralesional tumorectomy), 122 months after his initial intervention for a grade 2 CS. Finally, a patient died on Day 10 of palliative surgical revision for massive recurrence, seven months after inter-ilioabdominal disarticulation for a massive grade 2 myxoid CS.

Table 4 Postoperative complications.

	Amputation ($n = 11$)	Conservative treatment ($n = 48$)
Perioperative		
Hemorrhagic	1	1
Sciatic paralysis	0	2
Visceral wounds	2	1
Infectious		
Superficial	5	6
Deep	2	4
Mechanical		
Dislocations	0	6
Other	0	10

Discussion

Epidemiology

As observed, CSs are slightly male-predominant tumors, which affect mature adults with peak frequency in the fourth decade [2,3,5,7,17—20]. High-grade CS appears to be predominant in men after 50 years [21], which we also noted in our series.

In our series, 20% of CSs of the pelvic girdle occurred on a benign bone tumor, with an incidence varying between 9 and 32%, and was comparable to that found at the level

of the limbs [6,17,20—29]. Whereas there was no prognostic difference between primary and secondary CSs in our series, Sheth et al. [24] reported a better prognosis for secondary CS.

Treatment

The only treatment of CS, whatever its location, is surgical carcinological exeresis [3,5,6,17—19,23,24,30—40]. The survival of patients with CS of the pelvic girdle varies between 51% and 88% at 10 years [6,31,33,35,41]. It is lower than that of patients with peripheral CS (57% to 83%) [6,37,42,43].

Block resection with healthy surgical margins makes it possible to obtain the lowest rate of recurrence and better survival [6,24,31,33,35,39]. The rate of healthy margins is very variable in the literature, ranging from 25 to 82% [5,24,31,33,35]. The wide variability of these data is probably related to series inhomogeneity and operator experience as well as the practical difficulty of histologically characterizing resection margins. Intralesional surgery is a statistically significant risk factor for local recurrence [6,24,31,33,34,39,40].

The two series in the literature assigned to intralesional surgery of pelvic CS both concluded that this technique is ineffective [34,40]. This is also true for grade 1 CS for which it was originally proposed [40] and which concurs with our observations. Twelve out of 13 patients (92%) with inadequate margins had recurrences, and the sole patient who did not have recurrence died precociously (6 months) after his surgery, from causes unrelated to his disease (cerebrovascular accident).

Tumor location was also a significant prognostic factor.

Periacetabular location in our study was a statistically significant risk factor pejorative for survival. This was also the case for Mochizuki et al. [41]. For Sheth et al. [24], zone 3 CS is a poor prognostic factor for survival, and for Ozaki et al. [6], zone 3 location carries a greater risk of local recurrence, without the difference being statistically significant. This is probably due to the surgical difficulty in obtaining healthy margins in particular locations, unlike zone 1, which is easily accessible, with the exception of cases of crossing the sacroiliac articulation.

Taking these data into consideration, resection margin quality seems to be a major prognostic factor as much for the local control of CS as for patient survival.

Relapses

In this pelvic location, local recurrences are frequent: their incidence varies from 18 to 45% in the literature, and 31% in our experience [6,17,21,24,31,33,35,42,43].

We have observed that the risk of local recurrence is directly related to the quality of initially exeresis margins, which is corroborated by several studies [3,6,17,21,24,31,33,35,42,43].

In our work, local recurrence constituted a poor prognostic factor as it was statistically significantly associated with decreased survival, as demonstrated by other authors [5,31,33,35]. According to Fiorenza et al. [43], local recurrence affects survival in a pejorative manner when it is associated with one or more synchronous metastases. Only two studies have not provided evidence of the influence of local recurrence on survival [6,24].

According to Pring et al. [35], high-grade CSs are significant risk factors for local recurrence. Our study does not confirm these results.

Concerning treatment of local recurrence, we observed that patients undergoing surgical exeresis showed better survival than those who were not so treated, but the two study populations were too small in size to provide proof of a statistically significant difference.

Influence of surgical technique (amputation versus conservative treatment) on resection margin quality

Our series did not find evidence of a statistically significant difference between the two types of surgery to obtain healthy margins (63% for the amputation group versus 81% for the conservative surgery group) or in terms of survival. Many series arrived at the same conclusion [7,24,35,36,44,45]. Although these studies, as in our own experience, confirm the influence of surgical margins on local recurrence, none of them demonstrated the superiority of a technique in achieving healthy margins and concluded that conservative treatment as soon as possible should be preferred, to guarantee better functional results for a similar survival rate.

Two studies have reported the superiority of amputation over conservative surgery. In 1972, Marcove et al. [26] observed a statistically significant difference between interilioabdominal disarticulation and local resection for survival criteria. In 2005, Donati et al. [33] showed, in a series of 125 pelvic CSs, that radical surgery made it possible to obtain a higher level of healthy surgical margins (80% versus 61% for conservative surgery, $p = 0.077$), and a diminution of the local recurrence level. This result is at the limit of significance. Moreover, these two studies have the same limitations: the age of the records studied that is responsible for insufficiency of preoperative radiological assessment. It indeed appears logical that improvements in imaging techniques provide good assessments of margin quality and tumor resection before the intervention. According to the same reasoning, the use of navigation may improve the quality of exeresis [46,47]. However, Fiorenza et al. [43], in a series of 153 axial and peripheral CSs in 2002, did not manage to show that improved preoperative imaging associated with radical surgery made it possible to improve resection margins, the rate of local recurrence and survival.

It thus does not appear possible to conclude on the superiority of amputation both in terms of resection margin quality and survival. Our rare indications of first-intention amputation to date remain bulky tumours with vascular or nerve invasion, infected tumors or on radiation zones, in non-metastatic patients.

Function

As already reported in the literature [6,35,48,49], our series logically confirms that patients treated by conservative surgery have a higher functional score than those treated by amputation, and this in a sustainable manner. Indeed, among

patients treated by first-intention conservative surgery, 92% preserved their limb until the last follow-up. Studies published in the last 10 years objectively quantified the limb preservation level at the latest follow-up after initial conservative surgery, varying from 48 to 90% [6,24,33,35,41]. The large variability of these data is probably related to the great heterogeneity of these series.

Among the reconstructions, the functional results were worse than those concerning the acetabular zone. Zone 1 reconstructions only or isolated zone 3 resections without reconstruction had a better functional prognosis. These results conform with those reported in the literature [13,35], acetabular reconstruction remaining the main difficulty of reconstructive pelvic surgery [9,11,13,48—53].

Conclusion

The survival of patients with CS of the pelvis is related to local recurrence, initial tumor location and grade. The risk of local recurrence is related to resection margin quality.

The main objective of surgical treatment must thus be to obtain healthy resection margins, while preserving the limb and its function as much as possible.

There is no proof that inter-ilioabdominal disarticulation is superior to conservative surgery in terms of this objective and survival. On the other hand, conservative surgery gives better functional results than amputation without poor survival.

It is therefore not advisable to propose inter-ilioabdominal disarticulation when conservative surgery is achievable. Preoperative imaging will allow us to better appreciate lesion resection and the possibility of obtaining healthy margins.

The survival of patients treated for CS of the pelvic girdle remains lower than those with peripheral locations as it is more difficult to obtain healthy margins. The development of adjuvant treatments is particularly expected to limit the consequences of incorrect margins. Margin quality could gain with the use of peroperative navigation systems.

Conflicts of interest

None.

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