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ORIGINAL ARTICLE



# Meta-analysis of BCOR rearranged sarcomas: challenging the therapeutic approach

Anastasios Kyriazoglou[a] and Pantelis Bagos[b]

[a]Second Propaedeutic Department of Medicine, Attikon University Hospital, Chaidari, Athens, Greece; [b]Department of Computer Science and Biomedical Informatics, University of Thessaly, Lamia, Greece

**ABSTRACT**

**Introduction:** BCOR rearranged sarcomas comprise a group of malignant mesenchymal tumors that until recently were classified as Ewing sarcomas or as undifferentiated round cell sarcomas. The identification of alterations involving BCOR gene such as BCOR-CCNB3, BCOR-MAML3, ZC3H7B-BCOR fusion genes and BCOR internal tandem duplication (ITD) is characteristic for the differential diagnosis of BCOR rearranged sarcomas. Due to the rarity of these tumors there is no consensus or guidelines regarding the optimal therapeutic algorithm, that clinicians should follow.

**Patients and methods:** Herein we have conducted a meta-analysis of the current reports dealing with the therapeutic approach of BCOR rearranged sarcomas.

**Results:** Meta-analysis of the 57 eligible cases from 10 studies resulted to similar Incidence Rate Ratio (IRR) and overall survival (OS) for patients who received Ewing protocols and non-Ewing oriented treatment. Further similar death rate was reported for both strategies (non-Ewing 20% Vs Ewing 21.8%).

**Conclusion:** Our data support that non-Ewing treatment strategy can be considered a safe option, being at least equal to Ewing protocols. The current study provides a hint toward the optimal therapeutic approach of BCOR rearranged sarcomas. Further, the present study challenges the use of the term Ewing-like sarcomas, since the current literature supports that BCOR rearranged sarcomas deserve their own distinct classification in terms of genetics, pathology and therapy.

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## Introduction

BCOR rearranged sarcomas consist of a newly identified group of mesenchymal tumors, characterized by genetic alterations of BCOR gene [1]. Until recently, BCOR rearranged sarcomas were classified as undifferentiated round cell Ewing-like tumors or misclassified as Ewing sarcomas [2].

The detection of BCOR alterations such as *BCOR-CCNB3, BCOR-MAML3, ZC3H7B-BCOR* fusion genes and *BCOR* internal tandem duplication (ITD) is characteristic for the differential diagnosis of BCOR rearranged sarcomas [2–9]. BCOR rearranged sarcomas can arise both to bones and soft tissues [1]. Molecular pathology of these tumors is not crucial only for their diagnosis, but also indicative for the underlying molecular events driving the oncogenesis of this tumor entity [10,11]. BCOR fusion genes and BCOR ITD are the leading causes of cyclinD1 up-regulation and high mitotic activity [2,8,12].

Morphology and histopathology of BCOR rearranged sarcomas is a matter of dilemma for pathologists, since round cell sarcomas include Ewing sarcomas, BCOR sarcomas and CIC-DUX4 sarcomas sharing many similarities [13]. Though, it is clear that BCOR rearranged sarcomas have their own morphological and histopathological characteristics which differentiate them from the rest of round cell sarcomas [1,13]. Further, expression studies have shown that BCOR rearranged sarcomas share a distinct expression profile which is different from Ewing sarcomas [2,10].

The therapeutic approach of BCOR rearranged sarcomas is not well defined. There is no consensus or guidelines regarding the optimal therapeutic algorithm, highlighting the rarity of these tumors [14–17]. We have conducted a meta-analysis of the therapeutic strategy followed to every reported case of BCOR rearranged sarcoma. Our aim is to identify whether Ewing sarcoma treatment is superior to non-Ewing oriented sarcoma treatment, as reported in the current literature.

## Materials and methods

This study was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and the common practices in the field [18,19]. Eligible articles were identified by a search of MEDLINE bibliographical database for the period of 1 January 2000 up to 1 September 2020. The search strategy included the following keywords: BCOR AND (neoplasm OR cancer OR sarcoma) AND (chemotherapy OR systemic therapy OR management OR clinicopathologic OR molecular OR clinical).

CONTACT Anastasios Kyriazoglou tassoskyr@gmail.com Second Propaedeutic Department of Medicine, Attikon University Hospital, Chaidari, Athens, Greece

Two investigators (PB and AK), working independently, searched the literature and extracted data from each eligible study. Eligible articles were reviewed for clinicopathological data, treatment defined at least as Ewing or non-Ewing strategy and survival data of patients, in order to be included to the meta-analysis. Reviews, experts' opinion, case reports, prospective and retrospective studies were eligible for this meta-analysis if reported the appropriate data.

### Statistical analysis

Methods for meta-analysis of follow-up studies with constant or varying durations, where initially applied [20]. Since individual data could be extracted from the published reports, an individual patients' data (IPD) meta-analysis was performed. For categorical variables, data are presented as percentages, whereas for continuous variables as means and standard deviations (sd) [21]. To compare categorical variables, we used the Chi square test or Fisher's exact test where appropriate. To compare continuous variables, the t-test with unequal variances was used. Standard epidemiological methods comparing rates (Incidence Rate Ratio) were used. Survival curves were plotted and time-to-event analyses were estimated using the Kaplan–Meier method; differences between curves were analyzed using the log-rank test. Unadjusted and adjusted hazard ratios (HR) with the respective 95% CIs were estimated using Cox regression analysis. IRR and HR estimate the same population parameter, albeit by making slightly different assumptions [22,23]. In some cases, they are also referred to with the same name [24]. Moreover, the Poisson regression models with slightly different specifications are used for the meta-analysis of HR and IRR [20,25]. The Cox regression analysis examined the effect on OS after adjustment for all potential prognostic parameters at baseline. The following variables were considered in the regression analysis as following: (1) age (years); (2) advanced disease at diagnosis (stage IV = 1, non-metastatic disease = 0); (3) sex (male = 1, female = 0); (4) tumor type (soft tissue = 0, bone = 1). Statistical analyses were performed using Stata version 13.1. Statistical significance was defined as a $p$-value of less than .05 for all comparisons.

## Results

Our search identified 259 records, all of which remained after removing duplicate entries and excluding non-eligible articles from title and abstract screening. After application of our inclusion criteria by reviewing these potential articles in full-text, 17 articles were included for qualitative analysis. After searching the references of reviews and remaining research articles, no additional studied were identified. Seven articles were excluded due to lack of clinical or follow-up data. Finally, 10 published articles were eligible for the meta-analysis. The flowchart of the search and the selection of articles are depicted in Figure 1.

In total 57 cases were included in our analysis from 10 studies [3,4,7,26–32] (Table 1**).** Characteristics of the patients are summarized in Table 2. Only 2 of the included studies reported data for more than 10 patients, and consequently 7 of the studies had one or both arms with zero events (deaths). BCOR sarcomas were as expected more common to males (47 cases, 82%) than in females (10 cases, 18%). The median age at the time of diagnosis was 14 years (range: 2–71). Eight patients (14%) were diagnosed with de novo metastatic disease; while the majority (49 cases, 86%) had localized disease without signs of metastasis. Soft tissue tumors were 17 (30%), with bone tumors being the most common site of occurrence reported in 40 cases (70%). *BCOR-CCNB3* fusion gene was identified to 49 patients (86%), 3 cases harbored *ZC3H7B-BCOR* fusion (5%), 2 cases presented with BCOR ITD (3.5%), while *BCOR-MAML3*, *JAZF1-BCOR* and *CIITA-BCOR* were found to 1 patient (1.7%) respectively. Ewing sarcoma therapeutic approach was performed to 32 patients (56%). On the other hand, 25 patients (44%) received non-Ewing oriented treatment. The therapeutic approach of the latter patients is described in Table 3. Six of the de novo metastatic patients received Ewing sarcoma treatment (75%). Non-Ewing sarcoma therapeutic approach was administered to two patients with primary metastatic disease (25%). Eight patients with localized disease were treated solely with surgical excision of their tumor.

The application of summary-based methods for meta-analysis in such data is questionable. Applying the random effects Poisson-based regression method (which is an IPD method) resulted in non-significant estimates for the Incidence Rate Ratio comparing the treatments (IRR= 1.827, 95% CI: 0.502, 6.647). Taking into account the small sample and the fact that heterogeneity was virtually zero ($Q = 1.29$, $p$-value = .936, $I^2$=0), we decided to pool the data and treat the sample as a single cohort.

In the combined cohort the IRR remained larger than one (indicating higher risk for Ewing treatment) but still was far from significance (IRR = 1.176, 95% CI: 0.321, 4.700). Ewing treatment when compared to non-Ewing treatment showed similar survival (Figure 2). Seven deaths (21.8%) were reported for the group of patients that received Ewing oriented therapy, while 5 deaths (20%) occurred to the group of patients who received non-Ewing oriented therapy. The log-rank test yielded a non-significant $p$-value of .735 for the comparison of the survivor functions. As expected, the Cox proportional hazards model yielded similar results (HR = 1.219, 95% CI: 0.284, 3.870, $p = .736$). These remained unaltered even after adjusting for de novo metastatic cases. Sex, age, the site of primary tumor (bone or soft tissue), as well as the type of BCOR fusion, similarly did not influence the result of treatment option to BCOR sarcoma patients (data not shown, in all cases $p > .05$ was used in the multivariable Cox model and in a stepwise selection procedure). Other variables such as tumor size and mitotic count could not be evaluated, due to lack of data in the majority of included studies.

## Discussion

BCOR rearranged sarcomas are rare tumors with specific morphological and immunohistochemical characteristics, unique

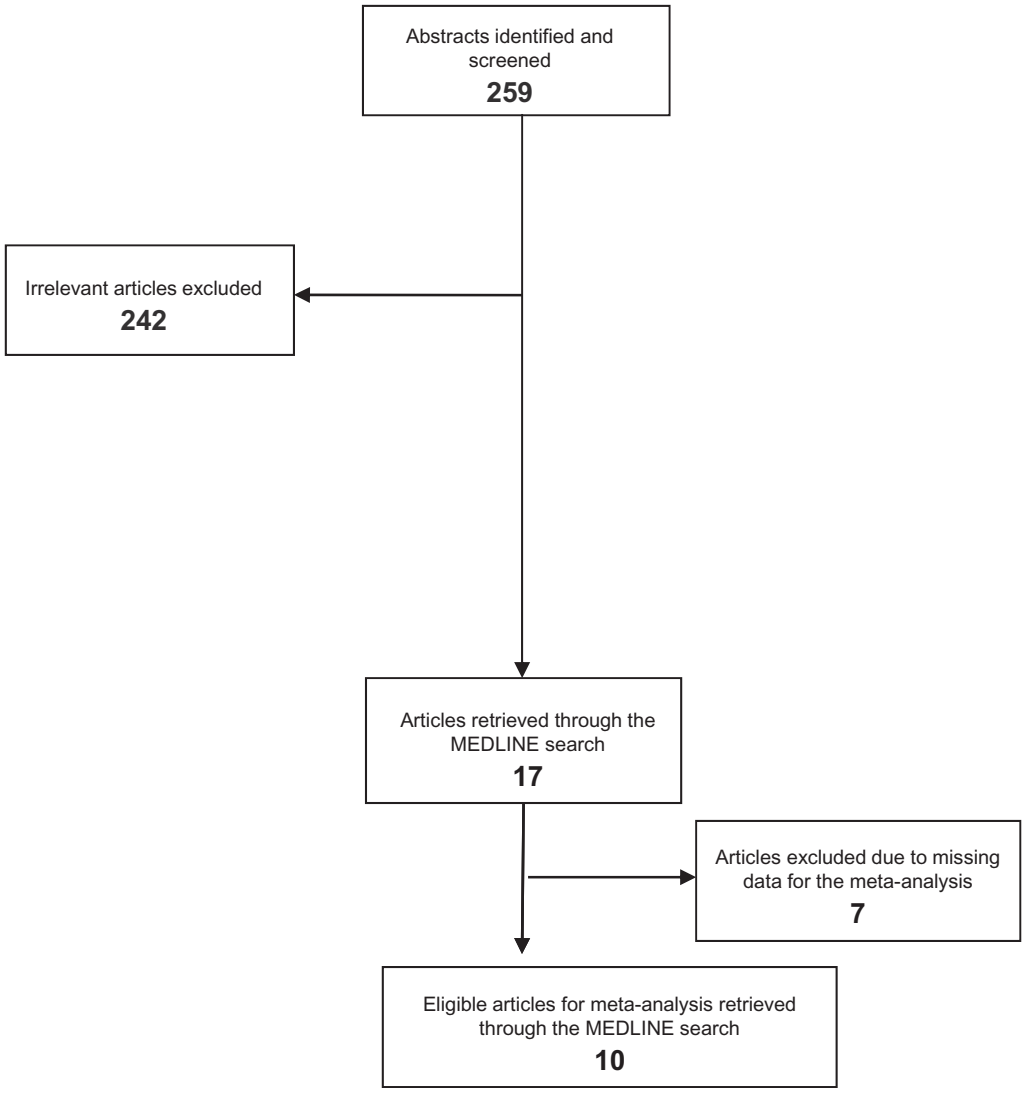


**Figure 1.** Schematic presentation of research strategy according to PRISMA guidelines.

**Table 1.** Main characteristics of the included studies.

| Study | Year | Country | Patients | Ewing protocol patients | Non-Ewing protocol patients |
|---|---|---|---|---|---|
| Kao *et al.* [7] | 2017 | USA | 21 | 11 | 10 |
| Yoshida *et al.* [23] | 2020 | Japan | 7 | 2 | 5 |
| Puls *et al.* [3] | 2014 | USA | 10 | 8 | 2 |
| Peters *et al.* [22] | 2014 | USA | 5 | 1 | 4 |
| Kyriazoglou *et al.* [28] | 2020 | Greece | 5 | 4 | 1 |
| Shibayama *et al.* [24] | 2015 | Japan | 3 | 3 | 0 |
| Specht *et al.* [4] | 2016 | Germany-USA | 2 | 1 | 1 |
| Mansor *et al.* [25] | 2018 | Singapore | 1 | 0 | 1 |
| Han *et al.* [26] | 2019 | USA | 2 | 2 | 0 |
| Muthukumarana *et al.* [27] | 2020 | USA | 1 | 0 | 1 |
| **Total** | | | **57** | **32** | **25** |

genetics and distinct expression pattern [1,2,8,10]. However, due to their morphological similarities with Ewing sarcomas, they are still classified as Ewing-like tumors [2]. Furthermore, the majority of the reported cases of BCOR rearranged sarcomas come from retrospective studies to which either they were misdiagnosed or were characterized under the wide term of undifferentiated round cell sarcomas (Table 2). Subsequently, a large percentage of cases were treated as Ewing sarcomas, while many cases received a different type of treatment (Table 2). This discrepancy depicts the impact of correct diagnosis to the appropriate treatment options in sarcomas [33]. Obviously, since BCOR rearranged sarcomas are recently identified, there are not guidelines or consensus regarding the therapeutic strategy of these tumors [14–17].

The goal of the current study was to evaluate the optimal treatment options based on the reported cases of the literature. The death rate of 20% for non-Ewing oriented protocols and 21.8% for Ewing oriented protocols validates the more favorable prognosis of BCOR rearranged sarcomas compared to Ewing sarcomas. Meta-analysis of the 57 eligible cases

**Table 2.** Clinicopathological parameters of the BCOR rearranged sarcoma patients.

| | All | Ewing treatment | Non Ewing treatment |
|---|---|---|---|
| **Number of patients** | 57 | 32 (56%) | 25 (46%) |
| **Age in years (range)** | 14 (2–71) | 15.2 (2–47) | 25 (2-71) |
| **Sex** | | | |
| Male | 47 (82%) | 28 (87.5%) | 19 (76.0%) |
| Female | 10 (18%) | 4 (12.5%) | 6 (24%) |
| **Tumor primary** | | | |
| Soft tissue | 17 (30%) | 8 (25%) | 9 (36%) |
| Bone | 40 (70%) | 24 (75%) | 16 (64%) |
| **Stage at diagnosis** | | | |
| Non metastatic | 49 (86%) | 26 (81%) | 23 (92%) |
| Metastatic | 8 (14%) | 6 (19%) | 2 (8%) |
| **Genetics** | | | |
| BCOR-CCNB3 | 49 (86%) | 31(97%) | 18 (72%) |
| BCOR ITD or BCOR other fusions[a] | 8 (14%) | 1 (3%) | 7 (28%) |

[a]BCOR other fusions include BCOR-MAML3, ZC3H7B-BCOR, JAZF1-BCOR, CIITA-BCOR.

**Table 3.** Summary of cases treated with non-Ewing oriented protocols.

| Reference case | Treatment | Chemotherapy |
|---|---|---|
| Yoshida *et al.* [23] | Surgery | No |
| Yoshida *et al.* [23] | Surgery, RT | No |
| Yoshida *et al.* [23] | Surgery, RT | No |
| Yoshida *et al.* [23] | Surgery | No |
| Yoshida *et al.* [23] | Chemo | Doxorubicin |
| Kao *et al.* [7] | Surgery, Chemo | Osteosarcoma neoadjuvant chemotherapy regimen |
| Kao *et al.* [7] | Surgery, Chemo | Methotrexate, cisplatin |
| Kao *et al.* [7] | Surgery, Chemo | Doxorubicin, ifosfamide |
| Kao *et al.* [7] | Surgery, Chemo | Doxorubicin, ifosfamide |
| Kao *et al.* [7] | Surgery, Chemo | Epirubicin, cyclophosphamide, nedaplastin |
| Kao *et al.* [7] | Surgery, Chemo | Ifosfamide, cisplatin |
| Kao *et al.* [7] | Surgery | No |
| Kao *et al.* [7] | Surgery | No |
| Kao *et al.* [7] | Surgery | No |
| Kao *et al.* [7] | Surgery | No |
| Puls *et al.* [3] | Surgery, Chemo, RT | Doxorubicin, ifosfamide, methotrexate |
| Puls *et al.* [3] | Surgery, Chemo, RT | Doxorubicin |
| Peters *et al.* [22] | biopsy-Chemo | Doxorubicin, ifosfamide |
| Peters *et al.* [22] | Surgery | No |
| Peters *et al.* [22] | Surgery (subtotal excision), Chemo | Doxorubicin, ifosfamide |
| Peters *et al.* [22] | Biopsy, Chemo | Vincristine, actinomycin-d, cyclophosphamide |
| Kyriazoglou *et al.* [28] | Surgery, Chemo | Vincristine, actinomycin-d, cyclophosphamide |
| Specht *et al.* [4] | Chemo, RT | Vincristine, doxorubicin, cyclophosphamide |
| Mansor *et al.* [25] | Surgery, Chemo | Doxorubicin |
| Muthukumarana *et al.* [27] | Surgery | No |

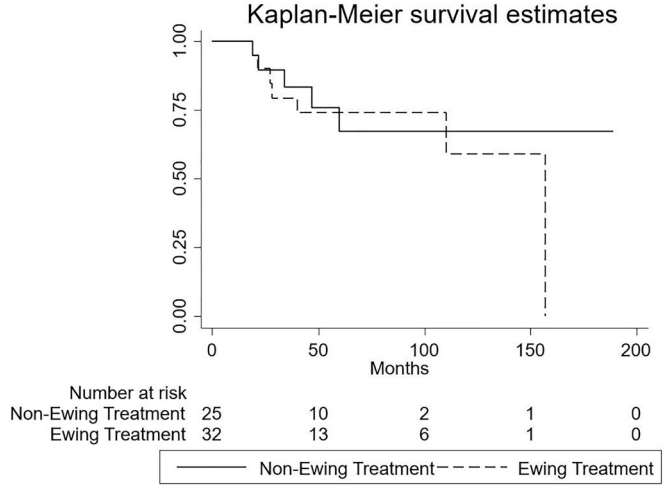


**Figure 2.** OS of patients with non-Ewing oriented regimens with bold line and Ewing treatment with intermittent line.

from 10 studies resulted to similar IRR and OS for patients who received Ewing protocols and non-Ewing oriented treatment. This conclusion is not only supported by the observation that chemotherapy with doxorubicin based regimens were administered with long survival outcomes, but also by the fact that many patients benefited only by surgical excision of the tumor (Figure 2). Even though our meta-analysis included only 8 de novo metastatic patients, this result remained even after adjusting for metastatic disease status. The current meta-analysis is opposed to the conclusion of Cohen-Gogo *et al.*, who retrospectively studied 26 *BCOR-CCNB3* cases [34]. The clinicopathological data of these cases were not adequately reported and unfortunately they were not included in our meta-analysis. It should be highlighted that the latter study included only patients with *BCOR-CCNB3* alteration, while our meta-analysis included patients harboring any type of BCOR fusion gene or BCOR ITD (Table 1).

Moreover, our analysis showed no significant differences when comparing BCOR-CCNB3 to the other types of BCOR alterations or treating each type separately.

Pierron *et al.*, in the very first report of BCOR-CCNB3 sarcomas reported that gene profiling and single nucleotide polymorphism (SNP) array analyses show a different pattern from Ewing sarcomas [2]. Watson *et al.*, in their study have performed RNA sequencing showing that BCOR rearranged sarcomas' expression pattern creates a cluster distinct from the rest small round cell sarcomas [10]. This cluster included *BCOR-CCNB3* cases, BCOR ITD, *BCOR-MAML3* and *ZC3H7B-BCOR* implying a common transcriptome driven by the underlying molecular events of BCOR rearrangements [10]. These results were further commented on a principal basis combining both biological and clinical data by Diaz-Martin *et al.*[11]. Authors raised the discrepancy of lack of a cell of origin for undifferentiated small round cell sarcomas and additionally the fact that the majority of fusion genes in sarcomas are transcriptional factors highlighting the necessity to study and fully understand the consequences of downstream signaling [11]. The exact mechanism by which BCOR alterations induce mitosis and cell increase is not yet fully elucidated [2,8,12,35,36]. However, the distinct morphology and immunohistochemistry, in combination with the unique genetics and expression pattern and additionally the different biologic disease behavior of BCOR rearranged sarcomas support the classification as a separate group of tumors [1,2,10].

Our data even though they come from a small amount of cases; support that non-Ewing sarcoma protocols could be considered a safe option for BCOR rearranged sarcomas. Chemotherapy with doxorubicin based regimens provides similar OS results with Ewing protocols and can be safely administered (Figure 2). Further, we are intrigued to highlight that the therapeutic strategy of localized cases of soft tissue tumors may include solely local excision, as it is indicated from the reports analyzed (4 cases with no evidence of disease, 2 cases alive with disease, 1 patient dead from other causes, 1 patient dead of the disease after 33 months). The current meta-analysis raises the question whether the term Ewing-like sarcomas is misleading, at least regarding the treatment approach of this tumor entity.

Of course, the present study has limitations. The current meta-analysis included retrospectively reported cases. Meaningful information was often not reported in the included case reports and as a result, even though we evaluated all the available covariates, some additional information may be missing. Pooled analysis was conducted mainly exploratorily, since it was based on patients with questionable comparability (age, sex and so on), stemming from various institutions globally, but this is unavoidable since we are dealing with a rare condition. We had to exclude 7 articles due to lack of therapeutic and clinical data for each case, thus decreasing the statistical power of our analysis. Perhaps, a combined collaborative effort that will pool properly all the available cases in an IPD meta-analysis would prove more powerful.

Our observations indicate that BCOR rearranged sarcomas deserve their own specific therapeutic approach. A prospective clinical trial studying the administration of Ewing protocols to non-Ewing treatment strategy will ideally define the optimal therapeutic option for these tumors. Moreover, we highlight the fact that BCOR rearranged sarcomas have been adequately introduced to the sarcoma community (basic scientists and clinicians), thus deserving theirindependence from Ewing sarcomas and the rest of the undifferentiated round cell sarcomas by limiting the use of the term Ewing-like sarcomas.

## Disclosure statement

The authors declare that they do not have any conflicts of interest.

## Data availability statement

Data are available upon request.

## References


[1] Marino-Enriquez A, Fletcher CD. Round cell sarcomas – biologically important refinements in subclassification. Int J Biochem Cell Biol. 2014;53:493–504.

[2] Pierron G, Tirode F, Lucchesi C, et al. A new subtype of bone sarcoma defined by BCOR-CCNB3 gene fusion. Nat Genet. 2012;44(4):461–466.

[3] Puls F, Niblett A, Marland G, et al. BCOR-CCNB3 (Ewing-like) sarcoma: a clinicopathologic analysis of 10 cases, in comparison with conventional Ewing sarcoma. Am J Surg Pathol. 2014;38(10):1307–1318.

[4] Specht K, Zhang L, Sung YS, et al. Novel BCOR-MAML3 and ZC3H7B-BCOR Gene Fusions in Undifferentiated Small Blue Round Cell Sarcomas. Am J Surg Pathol. 2016;40(4):433–442.

[5] Wong MK, Ng CCY, Kuick CH, et al. Clear cell sarcomas of the kidney are characterised by BCOR gene abnormalities, including exon 15 internal tandem duplications and BCOR-CCNB3 gene fusion. Histopathology. 2018;72(2):320–329.

[6] Astolfi A, Melchionda F, Perotti D, et al. Whole transcriptome sequencing identifies BCOR internal tandem duplication as a common feature of clear cell sarcoma of the kidney. Oncotarget. 2015;6(38):40934–40939.

[7] Kao YC, Owosho AA, Sung YS, et al. BCOR-CCNB3 Fusion Positive Sarcomas: A Clinicopathologic and Molecular Analysis of 36 Cases With Comparison to Morphologic Spectrum and Clinical Behavior of Other Round Cell Sarcomas. Am J Surg Pathol. 2018;42(5):604–615.

[8] Marino-Enriquez A, Lauria A, Przybyl J, et al. BCOR internal tandem duplication in high-grade uterine sarcomas. Am J Surg Pathol. 2018;42(3):335–341.

[9] Roy A, Kumar V, Zorman B, et al. Recurrent internal tandem duplications of BCOR in clear cell sarcoma of the kidney. Nat Commun. 2015;6:8891.

[10] Watson S, Perrin V, Guillemot D, et al. Transcriptomic definition of molecular subgroups of small round cell sarcomas. J Pathol. 2018 May;245(1):29–40.

[11] Diaz-Martin J, Biscuola M, Benoit J, et al. What's in a name? Molecular subclassification of sarcomas creates fresh challenges. J Pathol. 2019;247(4):409–412.

[12] Yamamoto Y, Tsuzuki S, Tsuzuki M, et al. BCOR as a novel fusion partner of retinoic acid receptor alpha in a t(X;17)(p11;q12) variant of acute promyelocytic leukemia. Blood. 2010;116(20):4274–4283.

[13] Yamada Y, Kuda M, Kohashi K, et al. Histological and immunohistochemical characteristics of undifferentiated small round cell sarcomas associated with CIC-DUX4 and BCOR-CCNB3 fusion genes. Virchows Arch. 2017;470(4):373–380.
[14] Casali PG, Abecassis N, Bauer S, ESMO Guidelines Committee and EURACAN, et al. Soft tissue and visceral sarcomas: ESMO-EURACAN Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol. 2018;29(Suppl 4):iv51–iv67.
[15] Casali PG, Bielack S, Abecassis N, ESMO Guidelines Committee, PaedCan and ERN EURACAN, et al. Bone sarcomas: ESMO-PaedCan-EURACAN Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol. 2018;29(Suppl 4):iv79–iv95.
[16] von Mehren M, Randall RL, Benjamin RS, et al. Soft tissue sarcoma, version 2.2016, NCCN clinical practice guidelines in oncology. J Natl Compr Canc Netw. 2016;14(6):758–786.
[17] Biermann JS, Chow W, Reed DR, et al. NCCN guidelines insights: bone cancer, version 2.2017. J Natl Compr Canc Netw. 2017;15(2):155–167.
[18] Moher D, Liberati A, Tetzlaff J, PRISMA Group, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097.
[19] Forero DA, Lopez-Leon S, Gonzalez-Giraldo Y, et al. Ten simple rules for carrying out and writing meta-analyses. PLoS Comput Biol. 2019;15(5):e1006922.
[20] Bagos PG, Nikolopoulos GK. Mixed-effects poisson regression models for meta-analysis of follow-up studies with constant or varying durations. Int J Biostat. 2009;5(1):1–35.
[21] Simmonds MC, Higgins JP, Stewart LA, et al. Meta-analysis of individual patient data from randomized trials: a review of methods used in practice. Clin Trials. 2005;2(3):209–217.
[22] Hernan MA. The hazards of hazard ratios. Epidemiology. 2010;21(1):13–15.
[23] Bender R, Beckmann L. Limitations of the incidence density ratio as approximation of the hazard ratio. Trials. 2019;20(1):485
[24] Hoffmann K, Pischon T, Schulz M, et al. A statistical test for the equality of differently adjusted incidence rate ratios. Am J Epidemiol. 2008;167(5):517–522.
[25] Crowther MJ, Riley RD, Staessen JA, et al. Individual patient data meta-analysis of survival data using Poisson regression models. BMC Med Res Methodol. 2012;12:34.
[26] Peters TL, Kumar V, Polikepahad S, et al. BCOR-CCNB3 fusions are frequent in undifferentiated sarcomas of male children. Mod Pathol. 2015;28(4):575–586.
[27] Yoshida A, Arai Y, Hama N, et al. Expanding the clinicopathologic and molecular spectrum of BCOR-associated sarcomas in adults. Histopathology. 2020;76(4):509–520.
[28] Shibayama T, Okamoto T, Nakashima Y, et al. Screening of BCOR-CCNB3 sarcoma using immunohistochemistry for CCNB3: A clinicopathological report of three pediatric cases. Pathol Int. 2015;65(8):410–414.
[29] Mansor S, Kuick CH, Lim SL, et al. ZC3H7B-BCOR-rearranged endometrial stromal sarcomas: a distinct subset merits its own classification? Int J Gynecol Pathol. 2019;38(5):420–425.
[30] Han H, Bertrand KC, Patel KR, et al. BCOR-CCNB3 fusion-positive clear cell sarcoma of the kidney. Pediatr Blood Cancer. 2020;67(4):e28151.
[31] Muthukumarana V, Fix DJ, Stolnicu S, et al. BCOR expression in mullerian adenosarcoma: a potential diagnostic pitfall. Am J Surg Pathol. 2020;44(6):765–770.
[32] Kyriazoglou A, Tourkantoni N, Liontos M, et al. A case series of BCOR sarcomas with a new splice variant of BCOR/CCNB3 fusion gene. In Vivo. 2020;34(5):2947–2954.
[33] Thway K, Noujaim J, Jones RL, et al. Advances in the pathology and molecular biology of sarcomas and the impact on treatment. Clin Oncol (R Coll Radiol)). 2017;29(8):471–480.
[34] Cohen-Gogo S, Cellier C, Coindre JM, et al. Ewing-like sarcomas with BCOR-CCNB3 fusion transcript: a clinical, radiological and pathological retrospective study from the Société Française des Cancers de L'Enfant. Pediatr Blood Cancer. 2014;61(12):2191–2198.
[35] Astolfi A, Fiore M, Melchionda F, et al. BCOR involvement in cancer. Epigenomics. 2019;11(7):835–855.
[36] Aldera AP, Govender D. Gene of the month: BCOR. J Clin Pathol. 2020;73(6):314–317.