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**Immunotherapy in biliary tract cancers: Current evidence and future perspectives**

Uson Junior PLS *et al.* Immunotherapy in biliary tract cancers

Pedro Luiz Serrano Uson Junior, Raphael L C Araujo

**Abstract**

Bile duct tumors comprises of tumors that originate from both intrahepatic and extrahepatic bile ducts and gallbladder tumors. These are aggressive tumors and chemotherapy is still the main treatment for advanced-stage disease, and most of cases have poor overall survival. Strategies aiming at treatments with better outcomes and less toxicity make immunotherapy an area of significant importance. Recent Food and Drug Administration approvals of immune checkpoint inhibitors (ICI) for agnostic tumors based on biomarkers such as microsatellite instability-high and tumor mutation burden-high are important steps in the treatment of patients with advanced bile duct tumors. Despite limited responses with isolated checkpoint inhibitors in later lines of systemic treatment in advanced disease, drug combination strategies have been demonstrating encouraging results to enhance ICI efficacy.

**Key Words:** Biliary tract cancer; Cholangiocarcinoma; Anti-programmed cell death protein-1; Anti-programmed death ligand-1; Microsatellite instability high; Tumor mutational burden high

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**Core Tip:** Chemotherapy remains the main treatment for advanced bile duct tumors, regardless of tumor aggressiveness, and poor overall survival rates. The Food and Drug Administration has approved immune checkpoint inhibitors (ICI) for agnostic tumors based on biomarkers such as microsatellite instability-high and tumor mutation burden-high. They are important steps in combined treatment with systemic chemotherapy for patients with advanced disease with encouraging results.

## **INTRODUCTION**

More than 905677 new cases of hepatobiliary cancer were estimated worldwide, including hepatocellular carcinoma (HCC), in 2020. In addition, more than 115949 new cases of gallbladder cancer (GC) were reported in the same period<sup>[1]</sup>. In the United States the incidence of patients diagnosed with liver and intra-hepatic tumors was estimated to be 42810 cases in 2020. Additionally, around 11980 patients were diagnosed with gallbladder and other biliary cancers<sup>[2,3]</sup>. The overall survival remains dismal with less than 10% of patients diagnosed with cholangiocarcinoma surviving 5 years after diagnosis<sup>[4,5]</sup>. Biliary tract cancers (BTC) comprise of a set of malignant tumors that can arise from any part of the bile ducts. BTC can be divided in intra-hepatic cholangiocarcinoma (ICC), peri-hilar cholangiocarcinoma, extra-hepatic cholangiocarcinoma (EHC), and GC.

In the last years, several advances have been made in the management of BTC particularly in relation to ICC. Furthermore, the personalized medicine aligned with new molecules have brought about new hope for patients with advanced disease. For patients with tumors harboring isocitrate dehydrogenase 1 (IDH-1) mutations, reported in about 25% of ICC, the IDH-1 mutant inhibitor ivosidenib was evaluated in a randomized phase 3 trial including patients with disease in progress after at least one previous treatment. Ivosidenib delayed progression of the disease compared to placebo<sup>[6,7]</sup>. For tumors harboring fibroblast growth factor receptor 2 (FGFR2) fusions, United States Food and Drug Administration (FDA) just approved inhibitor

pemigatinib that showed an objective response rate of 36% in a single arm cohort of 107 patients whom disease had progressed to previous chemotherapy treatment, of these patients 3 patients had complete response<sup>[8]</sup>. Multiple other FGFR inhibitors are under development and new agents will be incorporated in the landscape in the next years<sup>[9,10]</sup>.

Biliary cancers are desmoplastic tumors with an immunoresistant tumor microenvironment<sup>[4,11]</sup>. Besides, the liver has a great capacity of immunotolerance related to a continuous exposure to antigens derived from intestinal flora, and a large population of macrophages. This microenvironment actively contributes to the limited effect of checkpoint inhibitors in these tumors<sup>[4,12]</sup>. Hepatobiliary cancers have unique characteristics and components related to immune evasion. Tumor-associated macrophages were associated with higher tumor recurrence in a retrospective analysis in a small group of surgically resected hilar cholangiocarcinoma specimens, which also showed worse overall survival<sup>[13]</sup>. However, more precise and comprehensive evaluation of cellular components including myeloid-derived suppressor cells and natural-killer cells are necessary to drive conclusions of the impact of targeting to these cells in biliary cancers<sup>[4]</sup>. Immune checkpoint inhibitors (ICI), particularly anti-programmed cell death protein-1/programmed death ligand-1 (PD1/PD-L1), and anti-cytotoxic T-lymphocyte-associated protein 4 (CTLA4) antibodies have shown excellent results in HCC<sup>[14,15]</sup>. For this reason, most of the recent clinical trials in biliary cancers have been conducted with single ICI or combinations<sup>[16,17]</sup>. More recently, durvalumab also was evaluated with chemotherapy with exciting results in a randomized phase 3 trial in advanced biliary cancers<sup>[18,19]</sup>. The aim of this review is to cover the main studies of immunotherapy in biliary cancers, biomarkers of efficacy, future combinations, and strategies in advanced-stage disease.

## **TUMOR-AGNOSTIC BIOMARKERS**

*Microsatellite instability high*

Microsatellite-instability is a phenotype presented in cell with defective mismatch repair genes that result in a hypermutation state, and the prevalence of microsatellite instability high (MSI-H) in biliary tract cancers (BTC) ranges between 5%-10%<sup>[20]</sup>. The MSI-H phenotype can be germline (Lynch syndrome) or somatic<sup>[21,22]</sup>. Multiples studies have evaluated the effect of ICI in patients harboring MSI-H tumors. Recently, a randomized phase III trial demonstrated better outcomes in MSI-H metastatic colorectal cancer treated with upfront front-line therapy with pembrolizumab compared with the standard chemotherapy regimen<sup>[23]</sup>. Pembrolizumab is an anti PD-1 antibody, PD-1 is a cell surface protein presented in most activated T cells. When PD-L1 bound to the PD-1, this binding facilitates apoptosis and dysfunction of activated T cells, and mediates an immune suppressive microenvironment<sup>[24,25]</sup>. Therefore, binding PD-1 with an antibody may promote functional enhancement of activated T cells repairing anti-tumor immunity<sup>[24]</sup>.

In BTC, the efficacy of pembrolizumab in MSI-H was evaluated in different cohorts. In one study including 11 patients with advanced BTC MSI-H, the response rate (RR) was 27% (3/11) with response duration ranging between 11.6 to 19.6 mo<sup>[26]</sup>. Data from microsatellite instability in high BTC patients treated with the Keynote-158 with pembrolizumab showed better response rates. In a cohort of 22 patients, the objective response rate (ORR) was 40.9% (20.7-63.6), with complete response in 2 patients. The median progression-free survival (PFS) was 4.2 mo, with a median overall survival (OS) of 24.3 mo; however, the median duration of response was not reached<sup>[27]</sup>. A report of 4 BTC MSI-H patients was also included in a cohort of solid tumors treated with pembrolizumab, of patients one had complete response and the remaining three had stable disease<sup>[28]</sup>. Based on these evidence, immunotherapy should be considered for the treatment of advanced BTC patients with microsatellite instability high phenotype. All these studies included patients previously exposed to chemotherapy regimens, and evaluation of ICI in previous lines of systemic treatment in MSI-H BTC should be prospectively evaluated. Currently, pembrolizumab is approved by the FDA to treat

MSI-H BTC in cases that <sup>12</sup> progressed following prior treatment and those with no satisfactory alternative treatment options.

### *Tumor mutational burden high*

Tumor mutational burden (TMB) is a biomarker that measures and quantify the total mutation load in tumors. In biliary tract cancers TMB was evaluated retrospectively in a group of 156 patients. Of these, 133 tumoral tissues were assessed for TMB with next-generating sequencing. Forty-eight cases were GC, 58 were ICC and 50 were EHC. The mean TMB value was high among patients with GC, followed by EHC and ICC [7.1 vs 5.5 vs 3.9 mutations/megabase (mut/Mb),  $P < 0.05$ ]. The proportion of TMB high (TMB-H), defined in the study as 9.0 mut/Mb, was higher in GC than in ICC and EHC<sup>[29]</sup>. In another cohort, including 803 BTC patients, 160 patients were evaluated with whole-exome sequencing and 643 patients with hybrid capture-based comprehensive genomic profiling. The mean TMB was 3.0 (IQR: 0.8-6.1) mut/Mb. In this cohort, 4 of 6 patients with MSI-H phenotype had a response to the disease after immunotherapy of PD1 inhibitor<sup>[30]</sup>.

<sup>11</sup> In Keynote-158, a phase II basket study of pembrolizumab monotherapy for patients with advanced solid tumors, the relationship between activity of pembrolizumab and TMB was an exploratory endpoint. TMB-H was considered  $\geq 10$  mut/Mb. In the study, 790 patients had evaluable TMB included for efficacy analysis, and 102 patients (13%) were TMB-H. The ORR observed was 29% (21-39) for TMB-H and 6% (5-8) for TMB-low. In addition, median duration of response in months was not reached for TMB-H and was 33 mo in TMB-low, the <sup>7</sup> median OS for TMB-H and low was 11.7 mo (9.1-19.1) and 12.8 mo (11.1-14.1), respectively<sup>[31]</sup>. Based on these results, on June 16<sup>th</sup>, 2020, the <sup>2</sup> FDA approved pembrolizumab for the treatment of adult and pediatric patients with unresectable or metastatic TMB-H ( $\geq 10$  mut/Mb) solid tumors that showed progressed following the prior treatment and for those who have no satisfactory alternative treatment options. Despite being an important approval and option in the management of patients with advanced BTC, no BTC patients were evaluated in the TMB-H cohort.

With the approval and clinical utilization in practice future cohorts will bring insights about response rate and efficacy for this group of patients.

### **IMMUNE CHECKPOINT INHIBITORS CLINICAL TRIALS**

ICI were first evaluated in metastatic BTC patients whose disease have progressed on chemotherapy, and pembrolizumab was evaluated in two cohorts<sup>[32,33]</sup>. In the Keynote-028 <sup>5</sup> PD-L1-positivity (membranous PD-L1 expression in  $\geq 1\%$  of tumor and associated inflammatory cells or positive staining in stroma) was required for eligibility, at median follow-up time of 6.5 mo the ORR was 13% in 23 patients. The median OS was 6.2 mo (3.8-10.3) with a 12-mo OS rate of 27.6%. The grade  $\geq 3$  adverse events (AE) occurred in 16.7% of the patients<sup>[33]</sup>. In the Keynote-158, a total of 104 patients with advanced BTC who progressed disease on any lines of systemic treatment were treated with pembrolizumab. In that study, PD-L1 positivity was not mandatory, and 61 patients had PD-L1 combined positive score (CPS)  $\geq 1$ . The overall RR was 5.8% (2.1-12.1), six partial responses. Among patients with tumors with PD-L1 CPS  $\geq 1$  ( $n = 61$ ) the ORR was 6.6% (1.8-15.9) and in patients with tumors with PD-L1 CPS  $< 1$  ( $n = 34$ ), the ORR was 2.9% (0.1-15.3). The median OS was compared in patients with PD-L1 CPS  $\geq 1$  *vs*  $< 1$ , 7.2 mo (5.3-11.0) *vs* 9.6 mo (5.4-12.8), respectively. Overall, 13% of patients had Grade  $\geq 3$  AE<sup>[32]</sup>.

Equivalent results were obtained in another single center cohort including 40 patients. In this prospective cohort pembrolizumab was evaluated in advanced PD-L1  $\geq 1\%$  BTC patients who radiologically progressed after receiving first-line gemcitabine plus cisplatin. In the study, 47.5% of patients included had ECOG performance status  $\geq 2$ . The ORR <sup>9</sup> by Response Evaluation Criteria in Solid Tumor (RECIST) v1.1 was 10% and by immune-modified RECIST was 12.5%, and the median OS was 4.3 mo (3.5-5.1). OS did not statistically differ between groups in different biomarker analyses, including CPS or tumor proportion score<sup>[34]</sup>. <sup>14</sup> Anti-PD-1 nivolumab <sup>3</sup> was evaluated in a multi-site phase II study including 54 advanced BTC patients whose disease progressed while undergoing treatment with at least 1 Line but no more than 3 Lines of systemic therapy.

<sup>1</sup> Central independent review RR was 11% (5/46), and investigator-assessed (IA) review <sup>3</sup> response rate was 22% (10/46). Among the intention-to-treat population, median PFS was 3.68 mo (2.3-5.69) and median OS was 14.24 mo (5.98 to not reached). In this study, <sup>6</sup> samples with 1% or more tumor cells for PD-L1 and any tumor infiltrating lymphocytes (TILs) for PD-1 exhibiting membranous staining were considered biomarker positive. PD-L1 expression was associated with prolonged PFS ( $P < 0.001$ ). The PD-1 expression on TILs in this study had no correlation with clinical outcomes<sup>[35]</sup>. Although some responses were seen in these studies, immunotherapy with anti-PD-1 alone in unselected biomarker patients did not show great efficacy.

### **IMMUNE CHECKPOINT INHIBITORS COMBINED WITH CHEMOTHERAPY**

Combination of chemotherapy with ICI in BTCs are subject of study. A phase II study conducted in China evaluated the <sup>1</sup> anti-PD-1 camrelizumab with FOLFOX4 (fluorouracil plus oxaliplatin) in 47 chemotherapy naïve advanced BTC patients. In 43 patients available for RR analysis, the <sup>1</sup> confirmed response was achieved in 7%, with disease control rate of 67.4%. Median PFS and OS were not reached. Grade  $\geq 3$  AE occurred in 57.4% of the patients, the most commonly hematological count decreases<sup>[36]</sup>. Another study conducted in China evaluated the addition of anti-PD-1 antibodies to nab-paclitaxel and S1 in 32 patients with advanced BTC who were treated with anti-PD-1 inhibitors (pembrolizumab, nivolumab, sintilimab or toripalimab) plus nab-paclitaxel and S1, and in 26 patients who were treated with the combination chemotherapy alone. ORR were higher in the PD-1 inhibitors combination group (25%) compared with chemotherapy alone (15.3%). The median PFS was 5.4 mo in the group treated with anti-PD-1 compared to 2.82 mo in the group with chemotherapy alone ( $P = 0.01$ ). The median OS is not mature<sup>[37]</sup>.

Multiple mechanisms related to the synergism between chemotherapy and immunotherapy have been established. Chemotherapy can induce PD-L1 expression in cancer cells, facilitates infiltration of cytotoxic T cells in tumor microenvironment, and increase neoantigens and antigen-presenting cells, all these effects can enhance the PD-1

inhibition<sup>[38]</sup>. Further evaluation of this synergism, preliminary safety, and efficacy results of toripalimab and gemcitabine plus S-1 were presented<sup>[39]</sup>. In this phase II study, 34 patients were treated with the combination. Overall RR was 20.6% with a disease control rate (DCR) of 85.3%. In this study, patients with mutation on TP53 or ATM had shorter PFS than wild type<sup>[39]</sup>.

The TOPAZ-1 trial is a randomized phase 3 trial that evaluated the combination of durvalumab, an anti-PD-L1, with chemotherapy against chemotherapy alone in advanced BTC. The study presented at the 2022 ASCO Gastrointestinal Cancers Symposium met its primary endpoint, improving OS in this subgroup of patients. Median OS was 12.8 mo with the combination *vs* 11.6 mo with gemcitabine and cisplatin alone (HR 0.8,  $P = 0.021$ ). Furthermore, the addition of durvalumab to gemcitabine and cisplatin also improved PFS, 7.2 mo *vs* 5.7 mo (HR 0.75,  $P = 0.001$ ) and tumor responses, 26.7% *vs* 18.7%<sup>[19]</sup>.

### **IMMUNE CHECKPOINT INHIBITORS COMBINATIONS**

Another strategy to enhance anti-PD1/PD-L1 efficacy is combination with CTLA-4 inhibitors. This strategy has proposed that these combinations can enhance the activity and infiltration of cytotoxic T cells in tumor microenvironment in BTC<sup>[4]</sup>. Nivolumab plus ipilimumab was evaluated in a group of 39 metastatic BTC patients included in the CA 209-538 clinical trial for rare cancers. The primary endpoint was clinical benefit rate, exploratory endpoints included correlation of efficacy with biomarkers including PD-L1 expression and TMB. A total of thirty-three patients (85%) received at least one prior line of systemic treatment (0-2 Lines). The ORR was 24% and the clinical benefit rate was 45%. Responses were observed in all subgroups of BTC. The median OS and PFS were 6.1 and 3.1 mo, respectively. Other twenty-two (56%) patients experienced an immune-related adverse event, grade  $\geq 3$  AE were observed in 8 (20%) patients<sup>[40]</sup>.

The combination was further evaluated in a multi-institutional phase 2 trial with patients who had advanced BTC but without previous systemic therapy. Patients were distributed into two groups of treatment, the arm A was treated with gemcitabine,

cisplatin and nivolumab and patients received them every three weeks, for 6 mo, followed by nivolumab monotherapy that patients received every two weeks for a total duration of 2 years, the arm B consisted of nivolumab given for patients every two weeks and ipilimumab every six weeks for 2 years in case of no disease progression. The primary endpoint was PFS rate at 6 mo, and of patients 35 were treated in arm A and 36 patients treated in arm B. Progression-free survival rate at 6 mo was 70% in arm A and 18.6% in arm B. In addition, the observed PFS rates at 6 mo were insufficient to reject the null hypothesis in both arms<sup>[41]</sup>.

In another phase II study, combination of durvalumab, an anti-PD-L1 antibody, with tremelimumab, an anti-CTLA-4 antibody, with chemotherapy were evaluated in 121 chemotherapy naïve metastatic BTC patients<sup>[42]</sup>. In this study, patients were allocated in three groups of treatment. The first group, biomarker cohort (BMC) in which thirty patients were treated with cisplatin and gemcitabine for one cycle, following the next cycles with gemcitabine plus cisplatin, and durvalumab plus tremelimumab every three weeks until the disease progression. The second group, three combo cohort (3C), a total of 45 patients were treated with gemcitabine, cisplatin and durvalumab and the latter group, in the four-combo cohort (4C) including 46 patients, were treated with all the four drugs, chemotherapy with gemcitabine and cisplatin plus durvalumab and tremelimumab until disease progression or unacceptable toxicity. Overall, the addition of immunotherapy associated with chemotherapy on the first-line therapy was well tolerated and demonstrated to be a promising activity. The ORR was 50% (32.1-67.9) in the BMC group, 73.4% (60.5-86.3) in the 3C group, and 73.3% (60.4-86.2) in the 4C group. In addition, the DCR ranged between 96.7%-100%. The median PFS was 13 mo in the BMC group, 11 mo in the 3C group, and 11.9 mo in the 4C group. Median OS in the 4C group was 20.7 mo, 18.1 mo in the 3C group, and 15 mo in the BMC group. PD-L1 analysis before treatment did not show any association with PFS or OS. Interestingly, in the BMC group, a trend in higher PFS was observed after gemcitabine and cisplatin first cycle, in patients whose tumor had high expression of PD-L1 compared with patients with lower PD-L1. The main studies described are included on Table 1.

### **IMMUNE CHECKPOINT INHIBITORS COMBINED WITH ANTIANGIOGENICS**

Combination with antiangiogenics can enhance the immunotherapy effect, contributing to cytotoxic effect of lymphocytes on tumor microenvironment. After promising results in HCC, studies combining these agents are another option for refractory patients. In a non-randomized phase II study, 31 patients with chemotherapy refractory BTC were treated with lenvatinib, a tyrosine kinase inhibitor (TKI) with antiangiogenics properties, associated with pembrolizumab<sup>[43]</sup>. The combination showed an ORR of 10% (2-26). These patients had a median PFS of 6.1 mo and a median OS of 8.6 mo. The most frequent treatment-related AEs, as expected, included hypertension and immune mediated adverse events<sup>[43]</sup>. Similar results were observed with the combination of regorafenib, another TKI, with anti-PD-L1 avelumab<sup>[44]</sup>. In this phase II study, 34 heavily pretreated patients with advanced BTC were treated. Four (13.8%) achieved partial response. Hypertension and fatigue were the most common grade 3/4 AE.

### **FUTURE DIRECTIONS**

Most of the recruiting studies in advanced BTC tend to combine ICI with chemotherapy, in first-line systemic treatment or later lines. This combination has additional effects in enhancing ICI efficacy, as previously discussed<sup>[40,19]</sup>. Local ablative therapies and liver directed therapies are also strategies focused in enhancing neoantigens presentation and/or developing abscopal effect<sup>[45,46]</sup>. The main ongoing recruiting studies with different strategies and combinations with ICI are summarized in Table 2. In October 2021, interim analysis of the randomized phase III study TOPAZ-1, that evaluated cisplatin, gemcitabine, and durvalumab, against standard-of-care chemotherapy, demonstrated a significant OS benefit as a 1st-line treatment for patients with advanced biliary tract cancer<sup>[47]</sup>. Recently, final report confirmed that the addition of durvalumab to cisplatin and gemcitabine improved progression-free survival and overall survival compared to chemotherapy alone, with no safety concerns.

Based on the results of the TOPAZ-1 trial, upfront combination of chemotherapy with durvalumab could be considered a standard of care, however some concerns need to be further evaluated. First, it is clear that based on the curves of overall survival they began to separate around 6 mo, we need to consider that after 6 mo the control arm is placebo not chemotherapy, the HR was 0.91 for up to 6 mo and 0.74 thereafter. We don't know if continuing chemotherapy with the same regimen or a maintenance strategy would affect the results of the study. Second, more than a half of patients included in the study were intrahepatic cholangiocarcinoma, and more than half had PD-L1 score TAP (tumor area positivity) above 1. It is unclear if the study would have different results with more patients with PD-L1 score 0 or other underrepresented sites including extrahepatic cholangiocarcinoma or gallbladder. Third, in the subgroup analysis it seems that Asian patients derived more benefit from the combination than non-Asian patients, Asian patients comprehended half of the patients included in the study. Lastingly, no molecular analysis was presented, neither evaluation of underlying liver diseases including viral hepatitis or NASH<sup>[19]</sup>. This questions open future strategies of research to improve the care and understanding of immunotherapy in advanced biliary cancer patients.

## **CONCLUSION**

Immune checkpoint agnostic approvals for advanced-stage cancer with biomarkers such as MSI-H and TMB-H are important treatment options for patients with advanced BTC who currently has limited options for treatment of refractory disease. Drug combinations such as anti-PD-1/PD-L1 with anti-CTLA-4 and/or chemotherapy have the potential to establish the standard of care for these patients and benefit a larger proportion of individuals if adopted in earlier lines of systemic treatment, however, more studies are necessary to better identify subgroups of patients that will most benefit of these strategies of treatments.

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