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Pembrolizumab in combination with gemcitabine and cisplatin compared with gemcitabine and cisplatin alone for patients with advanced biliary tract cancer (KEYNOTE-966): a randomised, double-blind, placebo-controlled, phase 3 trial

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► **To cite this version:**

Robin Kate Kelley, Makoto Ueno, Changhoon Yoo, Richard Finn, Junji Furuse, et al.. Pembrolizumab in combination with gemcitabine and cisplatin compared with gemcitabine and cisplatin alone for patients with advanced biliary tract cancer (KEYNOTE-966): a randomised, double-blind, placebo-controlled, phase 3 trial. *The Lancet*, 2023, 401 (10391), pp.1853-1865. 10.1016/S0140-6736(23)00727-4 . hal-04089083

HAL Id: hal-04089083

<https://univ-rennes.hal.science/hal-04089083v1>

Submitted on 9 Jul 2024

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1 **Article Type:** Fast-track Article - Randomised Controlled Trial

2

3 **Title:** Pembrolizumab in combination with gemcitabine and cisplatin compared with gemcitabine
4 and cisplatin alone for advanced biliary tract cancer (KEYNOTE-966): a randomised, double-
5 blind, placebo-controlled phase 3 trial

6

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46

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54

55 **Summary**

56 **Background:** Biliary tract cancers, which arise from the intrahepatic or extrahepatic bile ducts
57 and the gallbladder, generally have a poor prognosis and are rising in incidence worldwide. The
58 standard-of-care treatment for advanced biliary tract cancer has been chemotherapy with
59 gemcitabine and cisplatin. Because most biliary tract cancers have an immune-suppressed
60 microenvironment, immune checkpoint inhibitor monotherapy is associated with a low objective
61 response rate. We conducted a study to determine whether adding the immune checkpoint
62 inhibitor pembrolizumab to gemcitabine and cisplatin would improve outcomes compared with
63 gemcitabine and cisplatin alone in biliary tract cancer.

64

65 **Methods:** The randomised, double-blind, placebo-controlled phase 3 KEYNOTE-966 study
66 enrolled participants with previously untreated unresectable, locally advanced or metastatic
67 biliary tract cancer at 175 medical centres globally. Eligible participants were randomised (1:1)
68 to pembrolizumab 200 mg or placebo, both administered intravenously every 3 weeks
69 (maximum, 35 cycles), in combination with gemcitabine (1000 mg/m² intravenously on days 1
70 and 8 every 3 weeks; no maximum duration) and cisplatin (25 mg/m² intravenously on days 1
71 and 8 every 3 weeks; maximum, 8 cycles). Randomisation was stratified by geographic region,
72 disease stage, and site of origin. The primary endpoint of overall survival was evaluated in the
73 intention-to-treat population. The secondary endpoint of safety was evaluated in the as-treated
74 population. This study is registered at ClinicalTrials.gov, number NCT04003636.

75

76 **Findings:** Between October 4, 2019, and June 8, 2021, 1069 participants were randomised to
77 pembrolizumab plus gemcitabine and cisplatin (pembrolizumab group; n=533) or placebo plus
78 gemcitabine and cisplatin (placebo group; n=536). Median study follow-up at final analysis was

79 25·6 months (IQR 21·7-30·4). Median overall survival was 12·7 months (95% confidence
80 interval [CI] 11·5-13·6) in the pembrolizumab group versus 10·9 months (95% CI 9·9-11·6) in
81 the placebo group (hazard ratio 0·83 [95% CI 0·72-0·95], one-sided p=0·0034 [significance
82 threshold, p=0·0200]). In the as-treated population, the maximum adverse event grade was 3-4
83 in 420 (79%) of 529 participants in the pembrolizumab group and 400 (75%) of 534 in the
84 placebo group and was grade 5 in 31 (6%) and 49 (9%) participants, respectively.

85

86 **Interpretation:** Based on a statistically significant, clinically meaningful improvement in overall
87 survival compared with gemcitabine and cisplatin without any new safety signals,
88 pembrolizumab plus gemcitabine and cisplatin could be a new treatment option for patients with
89 previously untreated metastatic or unresectable biliary tract cancer.

90

91 **Funding:** Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc., Rahway, NJ, USA.

92

93 **Panel: Research in Context**

94 **Evidence before this study:** We searched PubMed and Google Scholar on February 11, 2023,
95 for English-language publications of randomised, controlled trials published since database
96 inception using the terms “PD-1 inhibitor” OR “PD-L1 inhibitor” OR “immune checkpoint
97 inhibitor” AND “unresectable” OR “metastatic” AND “biliary tract cancer” OR “BTC” OR
98 “cholangiocarcinoma” OR “gallbladder cancer.” Several phase 2 trials of immune checkpoint
99 inhibitors for the treatment of biliary tract cancer were identified. The only phase 3 study was the
100 double-blind TOPAZ-1 trial of durvalumab plus gemcitabine and cisplatin versus placebo plus
101 gemcitabine and cisplatin in patients with previously untreated unresectable or metastatic biliary
102 tract cancer or with recurrent disease. Results of TOPAZ-1 showed that durvalumab plus
103 chemotherapy significantly improved overall survival versus placebo plus chemotherapy and
104 that the two treatment groups had similar safety profiles.

105
106 **Added value of this study:** KEYNOTE-966 is the first placebo-controlled study of a PD-1
107 inhibitor and the second study of a PD-1/PD-L1 pathway inhibitor to show a statistically
108 significant improvement in overall survival and a manageable safety profile in patients with
109 advanced biliary tract cancer. KEYNOTE-966 offers key findings beyond those of TOPAZ-1
110 owing to its larger population, enrolment of a greater proportion of participants outside of Asia,
111 the continuation of gemcitabine until disease progression, and more complete ascertainment of
112 important clinical biomarkers such as hepatitis B and C viral status, all of which may impact the
113 generalizability of outcomes to a global patient population.

114
115 **Implications of all the available evidence:** Results of KEYNOTE-966 add to the body of
116 evidence supporting the efficacy and safety of adding immune checkpoint inhibitors targeting
117 the PD-1/PD-L1 pathway to standard-of-care chemotherapy in the treatment of biliary tract
118 cancer. The statistically significant, clinically meaningful overall survival benefit observed in the

119 absence of new safety signals supports the combination of pembrolizumab, gemcitabine, and
120 cisplatin as a potential new first-line treatment option for patients with unresectable locally
121 advanced or metastatic biliary tract cancer.
122

123 **Introduction**

124 Biliary tract cancers, a complex family of epithelial malignancies arising from the intrahepatic or
125 extrahepatic bile ducts and gallbladder, have a generally poor prognosis.¹ Risk factors include
126 biliary tract injury secondary to chronic cysts or gallstones, liver fluke infection, and other
127 inflammatory aetiologies such as chronic viral hepatitis and cirrhosis.^{1,2} Beyond anatomic
128 heterogeneity, biliary tract cancers demonstrate substantial molecular heterogeneity, which is
129 influenced by location and aetiology.³⁻⁵ Although biliary tract cancers are uncommon, accounting
130 for <1% of all new cancer cases worldwide,⁶ the incidence is rising.^{1,2,7}

131
132 The chemotherapy combination of gemcitabine and cisplatin was established as the standard-
133 of-care first-line therapy for advanced biliary tract cancer more than ten years ago based on
134 results of the phase 3 ABC-02 study.⁸ In ABC-02, median overall survival was 11·7 months for
135 gemcitabine plus cisplatin versus 8·1 months for gemcitabine alone (hazard ratio [HR] 0·64,
136 $p < 0·001$). Despite extensive study, triplet chemotherapy regimens and combinations of targeted
137 therapies and chemotherapy do not improve efficacy compared with gemcitabine and
138 cisplatin.^{1,9-11} After disease progression, 5-fluorouracil-based combinations demonstrate only
139 modest efficacy.^{12,13} Patients with cancers harbouring specific molecular aberrations, including
140 *FGFR2* fusions, *IDH1* mutations, and mismatch repair deficiency, can derive benefit from
141 targeted therapies or immune checkpoint inhibitors based predominantly on activity observed in
142 studies conducted in the second-line or later setting.^{1,14,15} Because individual molecular subsets
143 are rare, treatment options are limited to chemotherapy for most patients.

144
145 The tumour microenvironment in most biliary tract cancers is characterized by
146 immunosuppressive or immune-excluded features,⁴ and response to inhibitors of programmed
147 cell death protein 1 (PD-1) and its ligand, PD-L1, given as monotherapy is correspondingly
148 low.¹⁶⁻¹⁸ Several chemotherapies, including gemcitabine and cisplatin, are known to modulate

149 the immune system through direct immunostimulatory mechanisms, downregulation of the
150 immunosuppressive microenvironment, and increased immunogenicity.^{19,20} These
151 immunomodulatory effects provide a strong rationale for combining immunotherapy and
152 chemotherapy, particularly in cancers with an immunosuppressive microenvironment. The
153 randomised, double-blind, phase 3 TOPAZ-1 study of patients with advanced biliary tract cancer
154 showed that adding the PD-L1 inhibitor durvalumab to gemcitabine and cisplatin significantly
155 improved overall survival compared with gemcitabine and cisplatin alone (median overall
156 survival 12·8 months in the durvalumab group vs 11·5 months in the placebo group; HR 0·80
157 [95% CI 0·66-0·97]; two-sided p=0·021).²¹

158
159 We assessed whether adding the anti-PD-1 monoclonal antibody pembrolizumab to
160 gemcitabine and cisplatin improved efficacy compared with gemcitabine and cisplatin alone as
161 first-line therapy for advanced biliary tract cancer.

162

163 **Methods**

164 *Study Design and Participants*

165 KEYNOTE-966 is a randomised, double-blind, placebo-controlled phase 3 study done at 175
166 medical centres in Asia-Pacific, Europe, North America, and South America (appendix pp 2-4).
167 Individuals were eligible for enrolment if they were aged ≥ 18 years, had histologically confirmed
168 unresectable locally advanced or metastatic extrahepatic cholangiocarcinoma (including mixed
169 hepatocellular carcinoma and cholangiocarcinoma), gallbladder cancer, or intrahepatic
170 cholangiocarcinoma, had disease measurable per Response Evaluation Criteria in Solid Tumors
171 (RECIST) version 1.1 determined by the investigator, had Eastern Cooperative Oncology Group
172 (ECOG) performance status 0 or 1, provided tumour tissue for biomarker assessment, had
173 adequate organ function, and had life expectancy >3 months. The only prior systemic therapy
174 permitted was neoadjuvant or adjuvant therapy completed ≥ 6 months before the diagnosis of

175 unresectable or metastatic disease. Individuals with past or ongoing hepatitis C virus (HCV)
176 infection were eligible. Individuals with controlled hepatitis B were eligible; this included
177 individuals who were positive for hepatitis B serum antigen (HBsAg) or had detectable hepatitis
178 B virus (HBV) DNA as long as they initiated antiviral therapy ≥ 4 weeks before starting study
179 therapy and their viral load was < 100 IU/mL. Individuals were excluded from enrolment if they
180 had ampullary cancer or had active autoimmune disease that required systemic treatment in the
181 previous two years. Full eligibility criteria are available in the protocol (appendix). Participants
182 self-reported their sex as female or male at birth.

183
184 The study protocol and its amendments, which included changes that affected study design
185 (summarized in the “Document History” section of the protocol [appendix]), were approved by
186 the appropriate local or national ethics body for each participating centre. All participants
187 provided written informed consent. The study was conducted in accordance with the Good
188 Clinical Practice requirements outlined by the International Council on Harmonisation, the
189 ethical principles originating with the Declaration of Helsinki, and all local regulations. Clinically
190 important protocol deviations occurred in 13 participants in the pembrolizumab group and 17
191 participants in the placebo group; these deviations were related to eligibility criteria, study drug
192 administration and discontinuation criteria, and trial procedures.

193
194 *Randomisation and masking*

195 Participants were randomised (1:1) to pembrolizumab or placebo by study investigators using a
196 central interactive voice-response system (Almac Clinical Technologies, Souderton, PA, USA)
197 and a randomisation list generated by the study funder. Randomisation was stratified by
198 geographic region (Asia vs non-Asia), disease stage (locally advanced vs metastatic), and site
199 of origin (extrahepatic vs gallbladder vs intrahepatic). Participants were randomised in blocks of
200 4 per stratum. Participants, investigators, and those collecting or analysing the data, including

201 representatives of the sponsor, were masked to treatment assignment. Local pharmacists were
202 aware of assignments to support treatment preparation. In the event of medical emergency,
203 treatment assignment could be unmasked by contacting an emergency unblinding call centre.
204

205 *Procedures*

206 Pembrolizumab 200 mg or saline placebo was administered intravenously once every three
207 weeks. Gemcitabine 1000 mg/m² and cisplatin 25 mg/m² were administered intravenously on
208 days one and eight of three-week cycles. All treatment was continued until disease progression,
209 unacceptable toxicity, investigator decision, withdrawal of consent, or other reason, whichever
210 occurred first; pembrolizumab and placebo were limited to 35 cycles, and cisplatin was limited to
211 eight cycles. Participants who discontinued gemcitabine, cisplatin, or both because of
212 unacceptable toxicity could continue pembrolizumab or placebo and vice versa. Participants
213 who stopped all study treatment were followed on-study unless they withdrew consent.

214 Crossover was not permitted. Full details regarding treatment decisions, including guidelines for
215 treatment interruption and discontinuation and dose reductions to manage adverse events (dose
216 reductions of pembrolizumab and placebo not permitted), are found in the protocol (appendix).

217
218 The presence of antibodies (IgG) against HCV was determined in blood during screening; HCV
219 viral load was determined if anti-HCV antibodies were present. The presence of antibodies (total
220 and IgM) against hepatitis B core antibody, HBV viral load, and HBsAg were determined in
221 blood during screening; guidelines for HBV assessment during study treatment are available in
222 the protocol (appendix). PD-L1 combined positive score (CPS) was determined in tumour tissue
223 using PD-L1 IHC 22C3 pharmDx (Agilent Technologies; Carpinteria, CA, USA). Microsatellite
224 instability (MSI) status was assessed in tumour tissue. The names and locations of the central
225 laboratories that tested HCV, HBV, PD-L1, and MSI status are summarized in the appendix (p
226 8).

227
228 Contrast-enhanced computed tomography (preferred) or magnetic resonance imaging of the
229 chest, abdomen, and pelvis was performed within 4 weeks before randomisation, 6 weeks after
230 first study treatment administration, then every 6 weeks through week 54 and every 12 weeks
231 thereafter. Contrast-enhanced magnetic resonance imaging (preferred) or computed
232 tomography of the brain and whole-body radionuclide bone scans were performed as clinically
233 indicated. Imaging was continued until disease progression assessed by RECIST version 1.1
234 according to masked independent central review, start of new anticancer therapy, death, or
235 withdrawal of consent. Survival was assessed every 12 weeks until death, withdrawal of
236 consent, or study end.

237
238 Physical examination and laboratory, haematology, and chemistry analyses were done during
239 screening, regularly during study treatment, and at the end of treatment according to the
240 protocol (appendix). Adverse events and laboratory abnormalities were assessed regularly
241 throughout treatment and up to 30 days after discontinuation (≤ 90 days for serious events in the
242 absence of new anticancer therapy), classified according to the *Medical Dictionary for*
243 *Regulatory Activities*, version 25.1, and graded according to the National Cancer Institute
244 Common Terminology Criteria for Adverse Events, version 5. Potentially immune-mediated
245 adverse events and infusion reactions were based on a list of terms prepared by the sponsor
246 and considered regardless of attribution to study treatment by the investigator.

247
248 *Outcomes*

249 The primary endpoint was overall survival, defined as time from randomisation to death due to
250 any cause. Secondary endpoints were progression-free survival, objective response rate, and
251 duration of response, all assessed according to RECIST version 1.1 per masked independent
252 central review, and safety. Progression-free survival was defined as time from randomisation to

253 first documented progressive disease or death due to any cause, whichever occurred first.
254 Objective response rate was defined as the proportion of participants with a best overall
255 response of complete or partial response. Duration of response was defined as the time from
256 first documented evidence of complete or partial response until disease progression or death
257 due to any cause, whichever occurred first. Change from baseline to week 18 in the global
258 health status/quality of life scale of the European Organisation for Research and Treatment of
259 Cancer 30-Item Core Quality of Life Questionnaire (EORTC QLQ-C30) was a prespecified
260 exploratory endpoint. The remaining prespecified exploratory endpoints are summarized in the
261 protocol (appendix) and will be presented in future publications.

262

263 *Statistical Analysis*

264 The overall type 1 error rate was strictly controlled at one-sided $\alpha=0.025$ for all overall survival,
265 progression-free survival, and objective response hypotheses using the graphical method of
266 Maurer and Bretz. All alpha was initially assigned to test overall survival. Per the multiplicity
267 diagram for alpha re-allocation (appendix p 5), if the overall survival comparison was significant,
268 alpha was reallocated to test progression-free survival and objective response rate. Within each
269 endpoint, type 1 error control across the interim and final analyses was maintained using the
270 minimum alpha spending strategy with a Lan-DeMets spending function approximating O'Brien-
271 Fleming boundaries. The one-sided p-value boundaries for declaring superiority of
272 pembrolizumab plus chemotherapy versus placebo plus chemotherapy were 0.0200 for overall
273 survival, 0.0125 for progression-free survival, and 0.0125 for objective response rate.

274 With enrolment of 1069 participants, based on a target of 818 deaths and two interim analyses
275 and assuming an exponential distribution of HR=1 for the first two months and HR=0.75 after
276 two months, the study had approximately 93% power to identify a significant overall survival
277 benefit for pembrolizumab plus gemcitabine and cisplatin at one-sided $\alpha=0.025$. With enrolment
278 of 1069 participants, based on a target of 786 events at the final progression-free survival

279 analysis and assuming an exponential distribution of HR=1 for the first two months and HR=0.7
280 after two months, the study had approximately 92% power to identify a significant progression-
281 free survival benefit for pembrolizumab plus gemcitabine and cisplatin at one-sided $\alpha=0.0125$.
282 With enrolment of 1069 participants and assuming an objective response rate of 25% in the
283 placebo group, the study had 91% power to detect a true difference in response rate of 10% at
284 one-sided $\alpha=0.0125$. The prespecified final analysis of progression-free survival and objective
285 response rate was at the first interim analysis. Post hoc analyses of progression-free survival
286 and objective response rate were performed at the final analysis.

287

288 Overall survival, progression-free survival, and duration of response were estimated using the
289 Kaplan-Meier method. Timepoints of interest were 12 and 24 months for overall survival, 6 and
290 12 months for progression-free survival and duration of response at the first interim analysis,
291 and 12 and 24 months for progression-free survival and duration of response at final analysis.
292 Censoring rules for overall survival, progression-free survival, and duration of response are
293 summarised in the appendix (p 9).

294

295 Between-group comparisons of overall survival and progression-free survival were assessed
296 using a stratified log-rank test; the magnitude of the treatment difference (i.e., the HR and 95%
297 CI) was calculated using a stratified Cox regression model with Efron's method of tie handling
298 and treatment as a covariate. Between-group comparisons of objective response rate were
299 assessed using the stratified Miettinen and Nurminen method with weights proportional to the
300 stratum size. The randomisation stratification factors were applied to the stratified log-rank test,
301 the stratified Cox regression model, and the stratified Miettinen and Nurminen method. To
302 assess consistency of the treatment effect, the protocol prespecified descriptive subgroup
303 analyses based on the stratification factors and other demographic and clinical characteristics.
304 An unstratified Cox model with treatment as a covariate was used to calculate the magnitude of

305 the treatment difference in each subgroup category; confidence intervals for subgroup analyses
306 were at the nominal 95% confidence level without adjustment for multiplicity. If the number of
307 participants in a subgroup category was <5% of the intention-to-treat population, subgroup
308 analysis was not performed for that category and the subgroup was not displayed in the forest
309 plot.

310

311 The full statistical analysis plan is available in the protocol (appendix). Efficacy was assessed in
312 the intention-to-treat population (ie, all participants randomised to a treatment group; only those
313 participants with a best overall response of complete or partial response were included in
314 analyses of duration of response. Safety and treatment exposure were assessed in the as-
315 treated population (ie, all randomised participants who received ≥ 1 dose of any study
316 treatment). An independent data and safety monitoring committee oversaw the study and
317 assessed efficacy and safety at prespecified interim analyses. After reviewing overall survival
318 results from the first and second interim analyses, the independent monitoring committee
319 reported that superiority for the pembrolizumab group was not achieved and recommended the
320 study continue as planned. Sample size and power calculations were performed using R
321 (version 3.6.1 with “gsDesign” version 3.0-5 and “simtrial” version 0.1.6 packages). Statistical
322 analyses were done using SAS (version 9.4). This study is registered with ClinicalTrials.gov
323 (number NCT04003636) and is ongoing but closed to enrolment.

324

325 *Role of the funding source*

326 In collaboration with the academic authors, authors employed by the study funder contributed to
327 study design, data analysis, data interpretation, and writing this report. The funder maintained
328 the study database and ensured data were collected according to the protocol. All authors had
329 access to the data and vouch for data accuracy and completeness, fidelity of the study to the

330 protocol and its amendments, and study conduct in accordance with Good Clinical Practice
331 guidelines.

332

333 **Results**

334 Between October 4, 2019, and June 8, 2021, 1069 participants were randomised to
335 pembrolizumab plus gemcitabine and cisplatin (pembrolizumab group; n=533) or placebo plus
336 gemcitabine and cisplatin (placebo group; n=536) and included in the intention-to-treat
337 population (figure 1). The as-treated population included 529 participants in the pembrolizumab
338 group (n=527 who received ≥ 1 dose of all study drugs and n=2 who received ≥ 1 dose of
339 pembrolizumab and gemcitabine only) and 534 participants in the placebo group (all
340 received ≥ 1 dose of all study drugs). Baseline demographics and participant characteristics
341 were generally balanced between treatment groups (table 1). Overall, 552 (52%) of 1069
342 participants were male, 567 (53%) were aged <65 years, 486 (45%) were enrolled in Asia, 943
343 (88%) had metastatic disease at enrolment, and 633 (59%) had tumours of intrahepatic origin
344 (table 1). Eight (2%) participants in the pembrolizumab group and five (1%) participants in the
345 placebo group had mixed hepatocellular carcinoma and cholangiocarcinoma.

346

347 Median study follow-up at final analysis, defined as time from randomisation to the December
348 15, 2022, data cutoff, was 25·6 months (IQR 21·7-30·4). In the as-treated population, 489 (92%)
349 of 529 participants in the pembrolizumab group and 504 (94%) of 534 participants in the
350 placebo group discontinued treatment, most commonly because of progressive disease (figure
351 1). Median treatment duration was 6·37 months (IQR 2·79-10·84) in the pembrolizumab group
352 and 5·54 months (IQR 2·53-9·69) in the placebo group. Median number of cycles administered
353 was 9·00 (IQR 4·00-16·00) and 8·00 (IQR 4·00-14·00), respectively. A summary of cycles
354 administered by treatment component is in the appendix (p 10). In the intention-to-treat

355 population, 253 (47%) of 533 participants in the pembrolizumab group and 261 (49%) of 536
356 participants in the placebo group received ≥ 1 subsequent anticancer therapy (appendix p 11).

357

358 At final analysis, 414 (78%) of 533 participants in the pembrolizumab group and 443 (83%) of
359 536 participants in the placebo group had died. Median overall survival was 12.7 months (95%
360 CI 11.5-13.6) in the pembrolizumab group and 10.9 months (95% CI 9.9-11.6) in the placebo
361 group; estimated 24-month overall survival rates were 25% (95% CI 21-29) and 18% (95% CI
362 15-22; figure 2A). The efficacy boundary for declaring a statistically significant overall survival
363 benefit for the pembrolizumab group was met (HR 0.83 [95% CI 0.72-0.95]; $p=0.0034$).

364 Descriptive subgroup analysis showed a benefit for the pembrolizumab group in most
365 prespecified subgroups, including those for PD-L1 CPS < 1 and CPS ≥ 1 (figure 2B).

366

367 With 361 (68%) of 533 participants in the pembrolizumab group and 391 (73%) of 536
368 participants in the placebo group having experienced a progression-free survival event at the
369 first interim analysis (median study follow-up as of the December 15, 2021, data cutoff, 13.6
370 months [IQR 9.7-18.4]), median progression-free survival was 6.5 months (95% CI 5.7-6.9) in
371 the pembrolizumab group and 5.6 months (95% CI 5.1-6.6) in the placebo group; estimated 12-
372 month progression-free survival rates were 25% (95% CI 21-30) and 20% (95% CI 16-24; figure
373 3). The efficacy boundary for declaring a statistically significant progression-free survival benefit
374 for the pembrolizumab group was not met (HR 0.86 [95% CI 0.75-1.00]; $p=0.023$). A post hoc
375 analysis showed similar outcomes for progression-free survival at the final analysis (HR 0.87
376 [95% CI 0.76-0.99]; appendix p 6).

377

378 At the first interim analysis, 153 (29% [95% CI 25-33]) of 533 participants in the pembrolizumab
379 group and 153 (29% [95% CI 25-33]) of 536 participants in the placebo group had complete or
380 partial response (table 2). The efficacy boundary for declaring a statistically significant objective

381 response rate benefit for the pembrolizumab group was not met (treatment difference 0·2 [95%
382 CI -5·2 to 5·6]; p=0·47). Median duration of response was 9·7 months (95% CI 6·9-12·2) in the
383 pembrolizumab group and 6·9 months (95% CI 5·7-8·2) in the placebo group (appendix p 7). At
384 final analysis, objective response rates were similar, and 24-month estimates of
385 ongoing response were 18% in the pembrolizumab group and 6% in the placebo group
386 (appendix pp 7 and 12).

387

388 In the as-treated population at the final analysis, adverse events of any cause occurred in 524
389 (99%) of 529 participants in the pembrolizumab group and 532 (<100%) of 534 participants in
390 the placebo group. The maximum toxicity grade was 3 or 4 in 420 (79%) participants in the
391 pembrolizumab group and 400 (75%) participants in the placebo group. Adverse events led to
392 death in 31 (6%) participants in the pembrolizumab group and 49 (9%) participants in the
393 placebo group (appendix p 13). Adverse events led to discontinuation of ≥ 1 study drug in 138
394 (26%) participants in the pembrolizumab group and in 122 (23%) participants in the placebo
395 group; discontinuation of all study drugs occurred in 35 (7%) and 39 (7%) participants,
396 respectively. Adverse events that occurred in $\geq 10\%$ of participants in either group are
397 summarized in table 3. No cases of HBV-associated hepatitis, defined as HBV reactivation plus
398 hepatitis flare by the American Association for the Study of Liver Diseases,²² were observed.

399

400 Treatment-related adverse events occurred in 493 (93%) of 529 participants in the
401 pembrolizumab group, including 369 (70%) with a maximum toxicity of grade 3 or 4, 102 (19%)
402 who discontinued ≥ 1 study drug, and 18 (3%) who discontinued all study drugs. Treatment-
403 related adverse events occurred in 500 (94%) of 534 participants in the placebo group, including
404 367 (69%) with a grade 3 or 4 event, 81 (15%) who discontinued ≥ 1 study drug, and 14 (3%)
405 who discontinued all study drug. Treatment-related adverse events led to death in 8 (2%)
406 participants in the pembrolizumab group and 3 (1%) participants in the placebo group (appendix

407 p 14). Treatment-related adverse events that occurred in $\geq 50\%$ of participants in either
408 treatment group were decreased neutrophil count (321 [61%] participants in the pembrolizumab
409 group and 320 [60%] participants in the placebo group) and anaemia (278 [53%] and 269 [50%]
410 participants, respectively; appendix p 13).

411
412 Potentially immune-mediated adverse events and infusion reactions occurred in 117 (22%) of
413 529 participants in the pembrolizumab group and 69 (13%) of 534 participants in the placebo
414 group, including 37 (7%) in the pembrolizumab group and 21 (4%) in the placebo group who
415 experienced a grade 3 or 4 event (appendix p 15). The only potentially immune-mediated event
416 that led to death was pneumonitis that occurred in 1 ($<1\%$) participant in the pembrolizumab
417 group. 48 (9%) participants in the pembrolizumab group and 26 (5%) participants in the placebo
418 group received systemic corticosteroids to manage immune-mediated adverse events and
419 infusion reactions. Corticosteroid use for individual immune-mediated AEs is in the appendix (p
420 16). Potentially immune-mediated AEs that occurred in $\geq 5\%$ of participants in either group were
421 hypothyroidism (46 [9%] participants in the pembrolizumab group and 14 [3%] participants in the
422 placebo group) and pneumonitis (26 [5%] and 10 [2%], respectively; appendix p 15).

423
424 Among evaluable participants in the pembrolizumab (n=518) and placebo (n=517) groups, least-
425 squares mean change from baseline to week 18 in the global health status/quality of life scale of
426 the EORTC QLQ-C30 was 2.5 (95% CI -4.5 to -0.5) in both the pembrolizumab and placebo
427 groups (difference in least-square means 0.0 [95% CI -2.5 to 2.6]).

428

429 **Discussion**

430 In the randomised, placebo-controlled phase 3 KEYNOTE-966 study, pembrolizumab plus
431 gemcitabine and cisplatin significantly improved overall survival compared with gemcitabine and
432 cisplatin alone as first-line therapy for unresectable locally advanced or metastatic biliary tract

433 cancer. The overall survival curves did not cross, separated early, and remained separated
434 throughout follow-up, with 24-month survival estimates of 25% in the pembrolizumab group and
435 18% in the placebo group. Median duration of response was also prolonged in the
436 pembrolizumab group (9·7 months vs 6·9 months at the first interim analysis). The overall
437 survival benefit of adding pembrolizumab to gemcitabine and chemotherapy was generally
438 consistent across most prespecified subgroups, including those based on geographic region
439 and disease aetiology. There was a trend towards improved benefit with pembrolizumab in
440 participants with intrahepatic tumour origin, although the 95% CIs for the intrahepatic,
441 extrahepatic, and gallbladder subgroups overlapped one another and the 95% CI for the
442 intention-to-treat population. Descriptive subgroup analyses should be interpreted with caution
443 because they were not adjusted for multiplicity and the trial was not powered to compare
444 outcomes in individual subgroups.

445
446 KEYNOTE-966 is only the third global phase 3 study to demonstrate a significant overall
447 survival improvement in biliary tract cancer. Following on TOPAZ-1, KEYNOTE-966 validates
448 the role of immune checkpoint inhibitors that target the PD-1/PD-L1 pathway in combination with
449 chemotherapy for treating advanced biliary tract cancer. KEYNOTE-966 and TOPAZ-1 are
450 similar in many aspects, but there are several differences. One difference is the gemcitabine
451 duration. In TOPAZ-1, gemcitabine was limited to eight cycles,²¹ whereas in KEYNOTE-966,
452 gemcitabine could be given until disease progression or intolerable toxicity, with no maximum
453 number of cycles. Overall, 43% of participants in the pembrolizumab group and 39% of
454 participants in the placebo group received ≥ 9 cycles of gemcitabine, including 32% and 27%,
455 respectively, who received ≥ 12 cycles. The different gemcitabine durations in KEYNOTE-966
456 and TOPAZ-1 reflect heterogeneity of clinical practice and provide complementary data that
457 accommodate different standards of care worldwide. KEYNOTE-966 stratified randomisation by
458 geographic region, whereas TOPAZ-1 did not. Further, KEYNOTE-966 enrolled a larger

459 proportion of participants outside of Asia (55% vs 45% in TOPAZ-1) and a larger number of
460 participants overall (n=1069 vs n=685).²¹ It is reassuring that the relative benefit of
461 pembrolizumab plus gemcitabine and cisplatin in the large non-Asian population was similar to
462 that observed in the intention-to-treat population. There was more complete ascertainment of
463 biomarkers in KEYNOTE-966, including PD-L1 and viral hepatitis status, which provides greater
464 confidence in the use of the combination in groups with and without these key covariates. The
465 shape of the overall survival curves and the time they separated was different between the
466 studies. In KEYNOTE-966, the curves separated in favour of the pembrolizumab group at
467 approximately month two and maintained a relatively consistent separation over time. In
468 TOPAZ-1, the curves crossed and did not separate in favour of the durvalumab group until
469 approximately month six and the relative benefit in the durvalumab group seemed to increase
470 with longer follow-up. For regions where gemcitabine continuation is standard-of-care, it is
471 reassuring that the benefit of adding pembrolizumab is maintained beyond month six. A notable
472 similarity between KEYNOTE-966 and TOPAZ-1 is the lack of a relationship between higher
473 PD-L1 expression and improved outcomes with chemoimmunotherapy. This is despite the use
474 of different PD-L1 assays and scoring methods in the two studies.²¹ The lack of relationship
475 between PD-L1 expression and outcomes to chemoimmunotherapy has been observed in other
476 tumour types, including non-small cell lung cancer.²³

477

478 There was a trend towards improved progression-free survival with pembrolizumab plus
479 gemcitabine and cisplatin at the first interim analysis of KEYNOTE-966, which was the
480 prespecified final analysis of progression-free survival, although the difference was not
481 statistically significant. The curves separated around month three and remained separated in a
482 post hoc analysis performed at the protocol-specified final analysis. Assessing progression-free
483 survival in biliary tract cancers is complex and often relies on non-radiographic factors such as
484 biliary obstruction, liver function, and serum carbohydrate antigen 19-9 expression. Thus,

485 progression-free survival assessed per RECIST version 1.1 may not be the best measure of
486 progression-free survival in biliary tract cancer. There was also no difference between treatment
487 groups in objective response rate. The objective response rate in the placebo group was higher
488 than that observed in TOPAZ-1²¹ but similar to that observed for gemcitabine and cisplatin in
489 other recent studies.^{24,25} Responses in the pembrolizumab group were more durable than those
490 in the placebo group, with 18% of responders in the pembrolizumab group and 6% of
491 responders in the placebo group estimated to be alive and without progressive disease at 24
492 months at the final analysis.

493
494 The adverse event profile of pembrolizumab plus gemcitabine and cisplatin was as expected
495 based on the known profiles of the individual treatment components, and the incidence of
496 adverse events was generally similar between groups. The most common adverse events were
497 blood count-related abnormalities, nausea, and fatigue, events known to be associated with
498 chemotherapy. As expected, potentially immune-mediated adverse events were more common
499 in the pembrolizumab group. These events were manageable with appropriate supportive
500 therapy. The use of systemic corticosteroids to manage immune-mediated adverse events was
501 generally low (used by <10% of participants in the as-treated population). Health-related quality
502 of life was maintained when pembrolizumab was added to gemcitabine and cisplatin.

503
504 Limitations of this study include the disproportionately larger enrolment of participants with
505 intrahepatic tumours compared with population frequencies,^{1,7} resulting in smaller sample sizes
506 for extrahepatic cholangiocarcinoma and gallbladder cancer that could impact subgroup
507 analysis. A bias in favour of intrahepatic tumours has been observed in other studies, including
508 TOPAZ-1²¹ and may reflect the rising incidence of intrahepatic cholangiocarcinoma worldwide.^{1,7}
509 The requirement for tumour tissue at study entry may have also contributed to a selection bias
510 for intrahepatic tumours because they are more accessible for tumour sampling. Given the low

511 prevalence of MSI-high biliary tract tumours,²⁶⁻³⁰ we were unable to assess outcomes by MSI
512 status because only ten participants with known MSI-high tumours were enrolled. Samples for
513 biomarker assessment were collected from consenting participants, and translational analyses
514 are ongoing. A dedicated analysis of complete patient-reported outcomes data will be presented
515 in the future.

516

517 In conclusion, KEYNOTE-966 met its primary endpoint as pembrolizumab plus gemcitabine and
518 cisplatin resulted in a statistically significant, clinically meaningful improvement in overall
519 survival compared with gemcitabine and cisplatin alone without new safety signals in
520 participants with previously untreated metastatic or unresectable biliary tract cancer.
521 Pembrolizumab plus gemcitabine and cisplatin could be a new treatment option for this
522 population.

523

524 **Contributors**

525 RKK, RSF, JF, ZR, JWV, LY, UM, ABS, and AV participated in the conception, design, and
526 planning of the study. RKK, CY, RSF, JF, ZR, SLC, JWC, JE, and AV served on the study
527 advisory committee. RKK, MU, CY, RSF, JF, ZR, TY, H-JK, SLC, MO, CV, MB, JOP, OB, UP,
528 JWV, JE, and AV enrolled and treated participants and acquired data. LY performed the
529 statistical analysis. RKK, MU, RSF, LY, UM, ABS, and AV analysed and interpreted the data.
530 RKK, LY, UM, and ABS verified the study data. RKK, MO, CY, RSF, JF, ZR, TY, H-JK, SLC,
531 MO, CV, MB, JOP, OB, UP, JWV, LY, UM, ABS, JE, and AV had access to the data, provided
532 critical review of the manuscript, and approved the submitted draft.

533

534 **Declaration of interests**

535 RKK, MU, BY, RSF, JF, ZR, TY, H-JK, SLC, MO, CV, MB, JOP, OB, UP, JWV, JE, and AV
536 report funding to their institution from Merck Sharp & Dohme LLC, a subsidiary of Merck & Co.,

537 Inc., Rahway, NJ, USA (MSD) to support conduct of this study. All authors received medical
538 writing and editorial support for the preparation of this manuscript from MSD. RKK additionally
539 reports advisory committee membership from MSD; grants or contracts to the institution from
540 Agios, AstraZeneca, Bayer, BMS, Eli Lilly, EMD Serono, Genentech/Roche, Loxo Oncology,
541 MSD, Novartis, Partner Therapeutics, QED, Relay Therapeutics, Surface Oncology, and Taiho;
542 consulting fees (advisory board payments) to self from Compass Therapeutics, Kinnate, Exact
543 Sciences, Regeneron, and Tyra Biosciences; consulting fees (advisory board or steering
544 committee payments) to institution from Agios, AstraZeneca, Exelixis, Ipsen, and MSD; travel
545 support from AstraZeneca and MSD; participation on a data safety monitoring board
546 (uncompensated) from Genentech/Roche and MSD; Scientific and Medical Advisory Board co-
547 hair (uncompensated) for the Cholangiocarcinoma Foundation; and member of Governance
548 Board (uncompensated) for the International Liver Cancer Association. MU additionally reports
549 grants or contracts to the institution from Taiho Pharmaceutical, AstraZeneca, Merck
550 Biopharma, MSD, Astellas Pharma, Eisai, Ono Pharmaceutical, Daiichi Sankyo, Novartis,
551 Boehringer Ingelheim, and J-pharma and payment or honoraria to self from Taiho
552 Pharmaceutical, AstraZeneca, Yakult Honsha, MSD, Nihon Servier, Ono Pharmaceutical,
553 Incyte, Chugai Pharmaceutical, Boehringer Ingelheim, J-pharma, Takeda Pharmaceutical,
554 Mylan EPD, Delta-Fly Pharma, and Novartis. CY additionally reports grants or contracts to self
555 from Servier, Bayer, AstraZeneca, Ono Pharmaceuticals, Celgene, Ipsen, Boryung
556 Pharmaceuticals, Ildong Pharmaceuticals, CKD Pharmaceuticals, and HH inno.N; consulting
557 fees to self from Servier, Bayer, AstraZeneca, MSD, Eisai, Celgene, Bristol Myers Squibb,
558 Debiopharm, Ipsen, Kyowa Kirin, Novartis, Boryung Pharmaceuticals, Merck Serono,
559 Mundipharma, Roche, and Janssen; and payment or honoraria to self from Servier, Bayer,
560 AstraZeneca, MSD, Eisai, Celgene, Bristol Myers Squibb, Debiopharm, Ipsen, Kyowa Kirin,
561 Novartis, Boryung Pharmaceuticals, Merck Serono, Mundipharma, Roche, and Janssen.

562 RSF additionally reports grants or contracts to the institution from Adaptimmune, Bayer, Bristol-
563 Myers Squibb, Eisai, Eli Lilly, Pfizer, Roche, and Genentech; consulting fees to self from
564 AstraZeneca, Bayer, Bristol-Myers Squibb, Exelixis, Cstone, Hengrui, Eisai, Eli Lilly, MSD,
565 Pfizer, Roche, and Genentech; payment or honoraria to self from Genentech; and participation
566 on a data safety monitoring or advisory board from AstraZeneca, and Hengrui. JF additionally
567 reports grants or contracts from Astellas, AstraZeneca, Incyte Biosciences Japan, Eisai, MSD,
568 Ono Pharmaceutical, Sanofi, J-Pharma, Daiichi Sankyo, Sumitomo Dainippon, Taiho
569 Pharmaceutical, Takeda, Delta-Fly Pharma, and Chugai Pharma; payment or honoraria from
570 Ono Pharmaceutical, Chugai Pharmaceutical, Incyte Biosciences Japan, Eisai, Eli Lilly Japan,
571 AstraZeneca, Yakult Honsha, Servier Japan, MSD, Novartis Pharma, Takeda, Bayer, Taiho
572 Pharmaceutical, EA Pharma, Teijin Pharma, Daiichi Sankyo, and Terumo; and participation on a
573 data safety monitoring board or advisory board from Onco Therapy Science, Chugai Pharma,
574 Astellas, AstraZeneca, Takara bio, Merck Bio, MSD, and Taiho Pharmaceutical. ZR additionally
575 reports consulting fees from MSD, AstraZeneca, and Roche and payment or honoraria for
576 lectures from Bayer, MSD, and Roche. TY additionally reports consulting fees from BMS, MSD,
577 AstraZeneca, Eisai, and Ipsen; support for attending meetings and/or travel from Roche and
578 Bayer; stock or stock options in Moderna; medical writing support from Taiho and Ipsen; and
579 payments to institution for clinical trial investigatorship from BMS, MSD, Exelixis, Eli Lilly,
580 AstraZeneca, Roche, and Taiho. H-JK additionally reports payment or honoraria to the
581 institution from MEDtalks and Ipsen and payments made to the institution for participation on an
582 advisory board from AstraZeneca, Janssen, MSD, and Ipsen. SLC additionally reports
583 consulting fees to self from MSD, AstraZeneca, Eisai, Roche, and Bayer; payment or honoraria
584 to self from MSD, AstraZeneca, Eisai, Roche, and Bristol-Myers Squibb; and support for
585 attending meetings and/or travel from Ipsen and Novartis. MO additionally reports payment or
586 honoraria from Taiho Pharmaceutical, Yakult Honsha, MSD, Ono Pharmaceutical, Nihon,
587 Servier, Bayer, and Pfizer. CV additionally reports consulting fees from Bayer, MSD, Roche,

588 Ipsen, and AstraZeneca and payment or honoraria from Bayer, MSD, Roche, Ipsen, and
589 AstraZeneca. MB additionally reports consulting fees from Bayer Pharma, MSD, Eisai, Sirtex
590 Medical, BMS, Roche, and AstraZeneca and payment or honoraria from Bayer Pharma, MSD,
591 Sirtex Medical, BMS, Roche, and AstraZeneca. JOP additionally reports grants or contracts
592 from BMS (Celgene), Servier, MedPacto, Eutilex, and ABL Bio; support for attending meetings
593 and/or travel from Minneamrita Therapeutics; and participation on a data safety monitoring
594 board or advisory board for AstraZeneca, Adicet, and Merck Serono. OB reports no additional
595 disclosures. UP reports no additional disclosures. JWV additionally reports consulting fees to
596 self from Ipsen, Novartis, AstraZeneca, Merck, Pfizer, PCI Biotech, Incyte, Keocyt, QED
597 Therapeutics, Pieris Pharmaceuticals, Genoscience Pharma, Mundipharma, Wren Laboratories,
598 Nucana, Debiopharm Group, Imaging Equipment Limited, Hutchison MediPharma, Zymeworks,
599 Aptitude Health, Sirtex Medical, Baxter, Medivir, Cantargia AB, Autem Medical, Taiho Oncology,
600 Servier, and Boehringer Ingelheim; payments to self for speakers bureaus from Novartis, Ipsen,
601 Nucana, Imaging Equipment Limited, Mylan, Incyte, Servier, and Delcath Systems; and support
602 for attending meetings and/or travel from Nucana, Lilly, Roche, and AstraZeneca/MedImmune.
603 LY additionally reports salary for full-time employment from MSD. UM additionally reports salary
604 for full-time employment from MSD and stock ownership in Merck & Co., Inc., Rahway, NJ,
605 USA. ABS additionally reports salary for full-time employment from MSD and stock ownership in
606 Merck & Co., Inc., Rahway, NJ, USA. JE additionally reports grants or contracts from BMS,
607 Beigene, and Boston Scientific and payment or honoraria from MSD, Eisai, BMS, AstraZeneca,
608 Bayer, Roche, Ipsen, Basilea, Merck Serono, Incyte, Servier, Beigene, Taiho, and Boston
609 Scientific. AV additionally reports consulting fees to self from AstraZeneca, Amgen, Beigene,
610 Böhringer Mannheim, BMS, BTG, Daiichi Sankyo, Eisai, Incyte, Ipsen, MSD, Pierre Fabre,
611 Roche, Servier, Sirtex, Taiho, and Terumo; payment or honoraria to self from AstraZeneca,
612 Amgen, Beigene, Böhringer Mannheim, BMS, BTG, Daiichi Sankyo, Eisai, GSK, Imaging
613 Equipment Ltd (AAA), Incyte, Ipsen, Jiangsu Hengrui Medicines, MSD, Pierre Fabre, Roche,

614 Servier, Sirtex, Taiho, and Terumo; and participation on a data safety monitoring board or
615 advisory board from AstraZeneca, Amgen, Beigene, Böhringer Mannheim, BMS, BTG, Daiichi
616 Sankyo, Eisai, Incyte, Ipsen, MSD, Pierre Fabre, Roche, Servier, Sirtex, Taiho, and Terumo.

617

618 **Data Sharing**

619 Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc., Rahway, NJ, USA (MSD) is
620 committed to providing qualified scientific researchers access to anonymized data and clinical
621 study reports from the company's clinical trials for the purpose of conducting legitimate scientific
622 research. MSD is also obligated to protect the rights and privacy of trial participants and, as
623 such, has a procedure in place for evaluating and fulfilling requests for sharing company clinical
624 trial data with qualified external scientific researchers. The MSD data sharing website (available
625 at: http://engagezone.msd.com/ds_documentation.php) outlines the process and requirements
626 for submitting a data request. Feasible requests will be reviewed by a committee of MSD
627 subject matter experts to assess the scientific validity of the request and the qualifications of the
628 requestors. In line with data privacy legislation, submitters of approved requests must enter into
629 a standard data-sharing agreement with MSD before data access is granted. Data will be made
630 available for request after product approval in the US and EU or after product development is
631 discontinued. There are circumstances that may prevent MSD from sharing requested data,
632 including country or region-specific regulations. If the request is declined, it will be
633 communicated to the investigator. Access to genetic or exploratory biomarker data requires a
634 detailed statistical analysis plan that is collaboratively developed by the requestor and MSD
635 subject matter experts; after approval of the statistical analysis plan and execution of a data-
636 sharing agreement, MSD will either perform the proposed analyses and share the results with
637 the requestor or will construct biomarker covariates and add them to a file with clinical data that
638 is uploaded to a SAS portal so that the requestor can perform the proposed analyses.

639

640

641 **Acknowledgments**

642 This study was funded by Merck Sharp & Dohme LLC, a subsidiary of Merck & Co., Inc.,
643 Rahway, NJ, USA (MSD). We thank the patients and their families and caregivers for
644 participating in the study; the investigators and site personnel; the members of the independent
645 data and safety monitoring committee; and the following employees of MSD: Melissa Buckland,
646 Shu-An Lin, and Jen Villetard for study support; Olga Kuznetsova, Saidi Palla, and Shuyan
647 (Sabrina) Wan for statistical support; Shital Kamble for input on health-related quality of life; and
648 Melanie A. Leiby for medical writing and editorial assistance.

649

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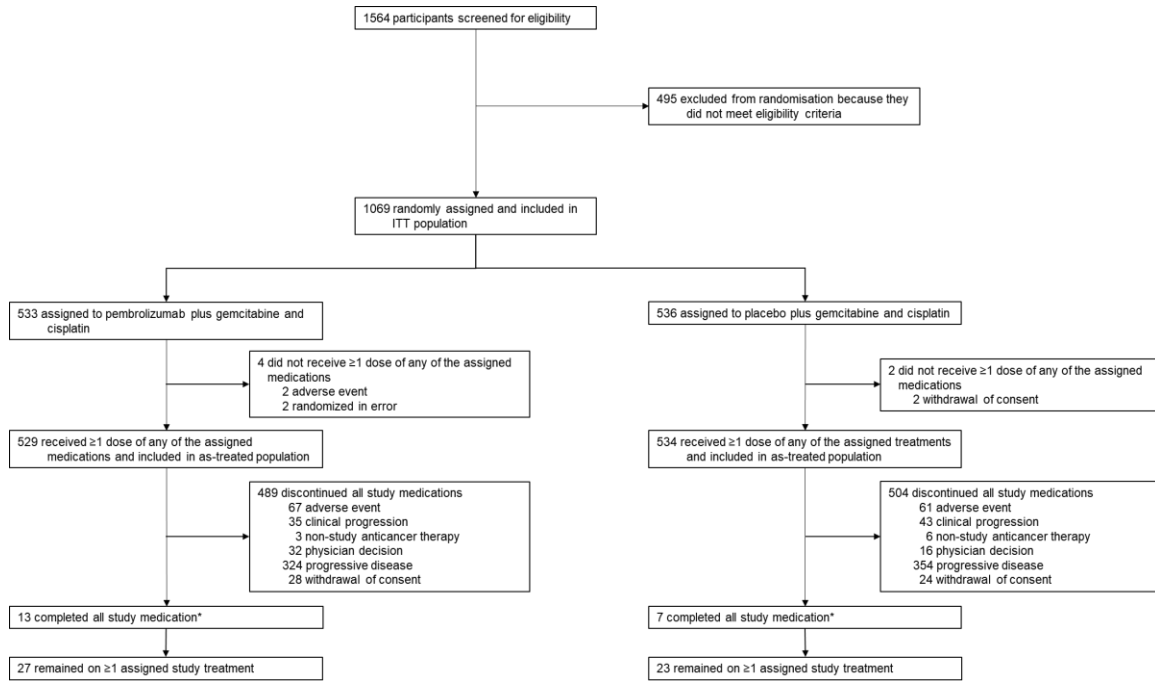
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733 **18**: 273.
- 734

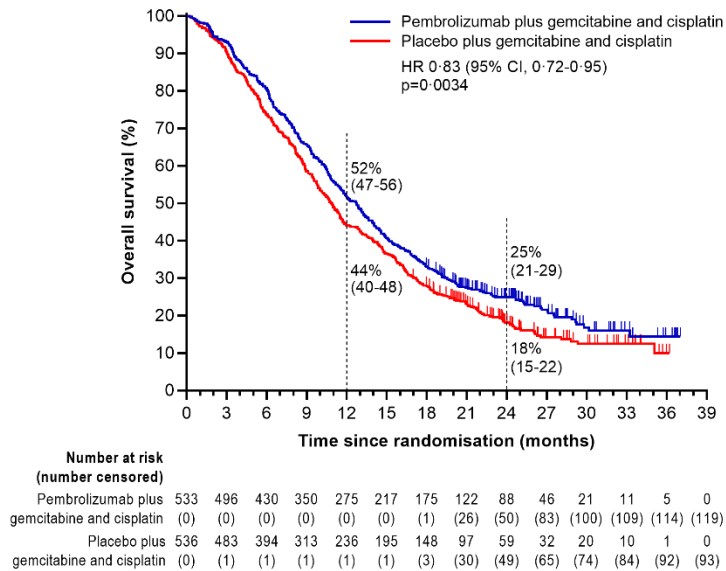
735 **Figure 1. Trial Profile.** *Completed includes participants who received 35 cycles of
 736 pembrolizumab or placebo without alternative reason for discontinuation of any drug if given
 737 beyond 35 cycles of pembrolizumab or placebo.



738
739

740 **Figure 2. Overall survival in the intention-to-treat population at the final analysis. (A)**
 741 Kaplan-Meier estimates of overall survival; tick marks indicate censored data. (B) Overall
 742 survival in subgroups for which all categories included $\geq 5\%$ of the intention-to-treat population,
 743 with the vertical grey shaded band indicating the 95% CI for the overall population. The analysis
 744 for the overall population is based on the same stratified Cox regression model as conducted for
 745 the primary analysis. Subgroup analyses were conducted using an unstratified Cox model with
 746 treatment as a covariate. The confidence intervals for the subgroups are at the nominal 95%
 747 confidence level without adjustment for multiplicity. ECOG=Eastern Cooperative Oncology
 748 Group.

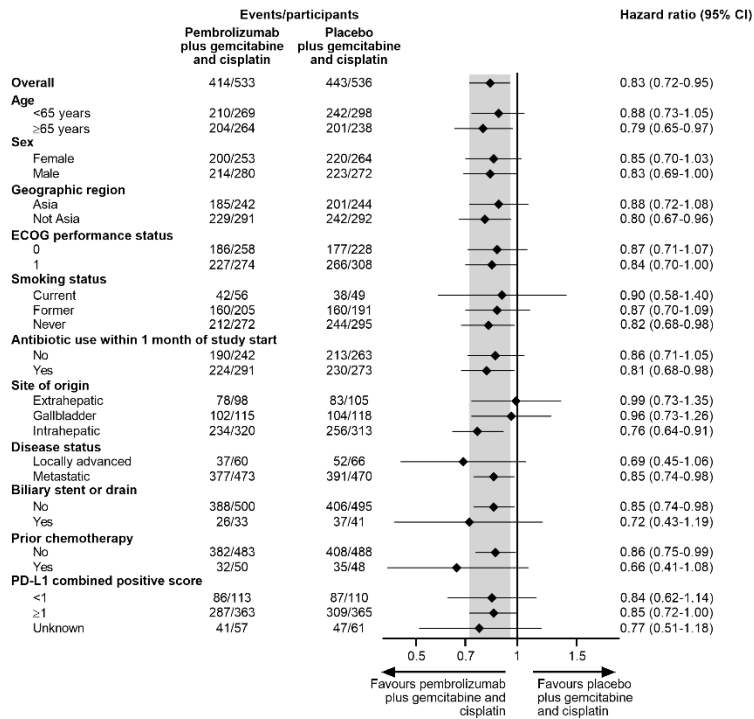
749 **A.**



750

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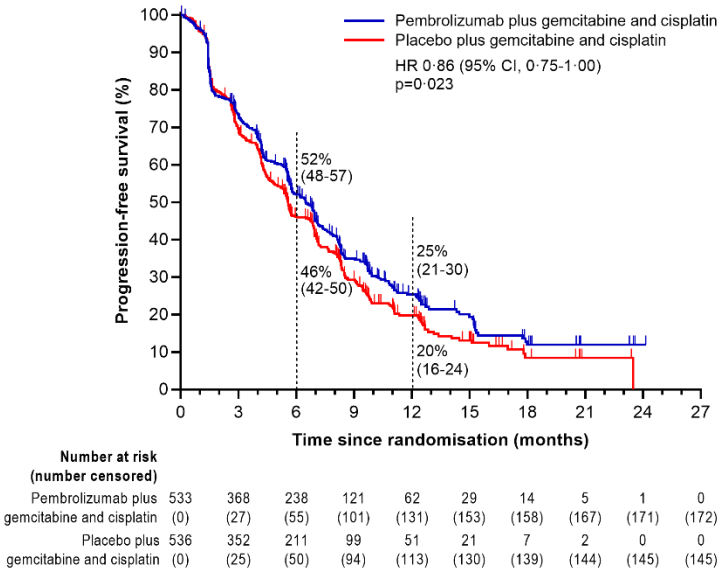
752 B.



753

754

755 **Figure 3. Kaplan-Meier estimates of progression-free survival assessed per masked**
 756 **independent central review in the intention-to-treat population at the first interim**
 757 **analysis. Tick marks indicate censored data.**



758

759

760 **Table 1. Baseline demographic and clinical characteristics in the intention-to-treat**
 761 **population**

	Pembrolizumab plus gemcitabine and cisplatin group (n=533)	Placebo plus gemcitabine and cisplatin group (n=536)
Age, years	64·0 (57·0-71·0)	63·0 (55·0-70·0)
<65	269 (50%)	298 (56%)
≥65	264 (50%)	238 (44%)
Sex		
Female	253 (47%)	264 (49%)
Male	280 (53%)	272 (51%)
Race		
American Indian or Alaskan Native	2 (<1%)	1 (<1%)
Asian	245 (46%)	250 (47%)
Black or African American	11 (2%)	3 (1%)
Multiple	5 (1%)	2 (<1%)
Native Hawaiian or Other Pacific Islander	1 (<1%)	0
White	256 (48%)	268 (50%)
Missing	13 (2%)	12 (2%)
Geographic region		
Asia	242 (45%)	244 (46%)
Not Asia	291 (55%)	292 (54%)
ECOG performance status		

	Pembrolizumab plus gemcitabine and cisplatin group (n=533)	Placebo plus gemcitabine and cisplatin group (n=536)
0	258 (48%)	228 (43%)
1	274 (51%)	308 (57%)
≥2	1 (<1%)	0
Site of origin		
Extrahepatic	98 (18%)	105 (20%)
Gallbladder	115 (22%)	118 (22%)
Intrahepatic	320 (60%)	313 (58%)
Disease status		
Locally advanced	60 (11%)	66 (12%)
Metastatic	473 (89%)	470 (88%)
Biliary stent or drain		
No	500 (94%)	495 (92%)
Yes	33 (6%)	41 (8%)
Prior chemotherapy administered as neoadjuvant or adjuvant therapy		
No	483 (91%)	488 (91%)
Yes	50 (9%)	48 (9%)
No prior photodynamic therapy	533 (100%)	536 (100%)
Prior radiation therapy		
No	512 (96%)	508 (95%)
Yes	21 (4%)	28 (5%)
Antibiotic use within 1 month of study start		

	Pembrolizumab plus gemcitabine and cisplatin group (n=533)	Placebo plus gemcitabine and cisplatin group (n=536)
No	242 (45%)	263 (49%)
Yes	291 (55%)	273 (51%)
MSI status		
MSI-H	6 (1%)	4 (1%)
MSS	433 (81%)	422 (79%)
Unknown	94 (18%)	110 (21%)
Hepatitis B status		
Any viral hepatitis B*	164 (31%)	165 (31%)
Chronic infection	14 (3%)	16 (3%)
Clinically resolved infection	150 (28%)	149 (28%)
No viral hepatitis B	366 (69%)	366 (68%)
Missing	3 (1%)	5 (1%)
Hepatitis C status		
Any viral hepatitis C†	19 (4%)	14 (3%)
Active infection	1 (<1%)	1 (<1%)
Prior infection	18 (3%)	13 (2%)
No viral hepatitis C	514 (96%)	520 (97%)
Missing	0	2 (<1%)
PD-L1 combined positive score		
<1	113 (21%)	110 (21%)
≥1	363 (68%)	365 (68%)

	Pembrolizumab plus gemcitabine and cisplatin group (n=533)	Placebo plus gemcitabine and cisplatin group (n=536)
Unknown	57 (11%)	61 (11%)

762 Data are median (IQR) or n (%). ECOG=Eastern Cooperative Oncology Group.

763 MSI=microsatellite instability. MSI-H=microsatellite instability high. MSS=microsatellite stable.

764 *Chronic hepatitis B infection included participants positive for hepatitis B surface antigen or

765 who had hepatitis B DNA ≥ 20 IU/mL. Clinically resolved hepatitis B infection included

766 participants positive for hepatitis B core antibody and negative for hepatitis B surface antigen

767 with hepatitis B DNA < 20 IU/mL. †Chronic hepatitis C infection included participants positive for

768 hepatitis C IgG antibody and a numeric value for hepatitis C virus RNA. Prior hepatitis C

769 infection included participants positive for hepatitis C IgG antibody but undetectable hepatitis C

770 virus RNA.

771

772 **Table 2. Summary of response in the intention-to-treat population at the first interim**
 773 **analysis.**

	Pembrolizumab plus gemcitabine and cisplatin group (n=533)	Placebo plus gemcitabine and cisplatin group (n=536)
Objective response rate	153 (29% [25-33])	153 (29% [25-33])
Disease control rate	399 (75% [71-79])	407 (76% [72-80])
Best overall response		
Complete response	11 (2%)	7 (1%)
Partial response	142 (27%)	146 (27%)
Stable disease*	246 (46%)	254 (47%)
Progressive disease	102 (19%)	96 (18%)
Not evaluable†	8 (2%)	9 (2%)
Not assessed‡	24 (5%)	24 (4%)
Time to response, months	2·8 (1·5-4·1)	2·8 (1·5-4·2)
Duration of response,§ months	9·7 (6·9-12·2)	6·9 (5·7-8·2)
Extended duration of response§		
≥3 months	93%	91%
≥6 months	67%	56%
≥9 months	51%	39%
≥12 months	41%	28%

774 Data are n (% [95% CI]), n (%), median (IQR) (for time to response), median (95% CI) (for
 775 duration of response), or %. *Stable disease includes participants with stable disease, non-
 776 complete response or non-progressive disease, and no evidence of disease. †Not evaluable

777 includes participants whose post-baseline imaging assessments were not evaluable for best
778 overall response. ‡Not assessed includes participants for whom no post-baseline imaging
779 assessments were available. §Estimated using the Kaplan-Meier method.

Table 3. Adverse events of any cause that occurred in $\geq 15\%$ of participants in either treatment group in the as-treated population at the final analysis

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)				Placebo plus gemcitabine and cisplatin group (n=534)			
	Grade 1-2	Grade 3	Grade 4	Grade 5	Grade 1-2	Grade 3	Grade 4	Grade 5
Any event	73 (14%)	287 (54%)	133 (25%)	31 (6%)	83 (16%)	270 (51%)	130 (24%)	49 (9%)
Decreased neutrophil count	73 (14%)	167 (32%)	90 (17%)	0	74 (14%)	171 (32%)	82 (15%)	0
Anaemia	171 (32%)	150 (28%)	2 (<1%)	0	159 (30%)	150 (28%)	4 (1%)	0
Nausea	221 (42%)	12 (2%)	0	0	234 (44%)	12 (2%)	0	0
Decreased platelet count	117 (22%)	64 (12%)	30 (6%)	0	105 (20%)	67 (13%)	40 (7%)	0
Fatigue	161 (30%)	25 (5%)	1 (<1%)	0	150 (28%)	22 (4%)	0	0
Constipation	184 (35%)	2 (<1%)	0	0	187 (35%)	3 (1%)	0	0
Decreased appetite	137 (26%)	6 (1%)	1 (<1%)	0	140 (26%)	15 (3%)	0	0
Decreased white blood cell count	80 (15%)	57 (11%)	4 (1%)	0	80 (15%)	44 (8%)	3 (1%)	0

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)				Placebo plus gemcitabine and cisplatin group (n=534)			
	Grade 1-2	Grade 3	Grade 4	Grade 5	Grade 1-2	Grade 3	Grade 4	Grade 5
Pyrexia	127 (24%)	12 (2%)	0	0	99 (19%)	5 (1%)	0	0
Vomiting	108 (20%)	14 (3%)	0	0	121 (23%)	7 (1%)	0	0
Diarrhoea	92 (17%)	11 (2%)	0	0	87 (16%)	10 (2%)	0	1 (<1%)
Abdominal pain	82 (16%)	10 (2%)	0	0	103 (19%)	19 (4%)	0	0
Rash	87 (16%)	3 (1%)	0	0	47 (9%)	2 (<1%)	0	0
Increased aspartate aminotransferase	72 (14%)	16 (3%)	0	0	77 (14%)	19 (4%)	2 (<1%)	0
Increased alanine aminotransferase	75 (14%)	12 (2%)	0	0	99 (19%)	14 (3%)	0	0
Hypomagnesaemia	74 (14%)	5 (1%)	0	0	73 (14%)	5 (1%)	1 (<1%)	0
Pruritus	77 (15%)	0	0	0	51 (10%)	0	0	0
Asthenia	64 (12%)	10 (2%)	1 (<1%)	0	76 (14%)	19 (4%)	0	0

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)				Placebo plus gemcitabine and cisplatin group (n=534)			
	Grade 1-2	Grade 3	Grade 4	Grade 5	Grade 1-2	Grade 3	Grade 4	Grade 5
Peripheral oedema	73 (14%)	0	0	0	78 (15%)	7 (1%)	0	0

Data are n (%).

Supplemental Appendix

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Study Protocol	17

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	Gallipoli Medical Research Foundation	Joubert, Warren
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	Mid North Coast Cancer Institute	Begbie, Stephen
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	UZ Leuven	Verslype, Chris
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	A.C. Camargo Cancer Center	Camandaroba, Marcos
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	First Affiliated Hospital of the Third Military Medical University	Liang, Houjie
	The First Hospital of Jilin University	Li, Wei
	Hunan Cancer Hospital	Gu, Shanzhi
	Harbin Medical University Cancer Hospital	Bai, Yuxian
	Zhejiang Cancer Hospital	Ying, Jieer
	The First Affiliated Hospital Zhejiang University	Liang, Tingbo
	The 900th Hospital of the Joint Logistics Support Force of the Chinese People's Liberation Army	Li, Dongliang
	Beijing Cancer Hospital	Hao, Chunyi
	Anhui Provincial Hospital	Pan, Yueyin
	Hunan Provincial People Hospital	Peng, Chuang
	The First Affiliated Hospital of Xi'an Jiaotong University	Geng, Zhimin
	Tangdu Hospital	Su, Haichuan
	West China Hospital of Sichuan University	Gou, Hongfeng
	Peking Union Medical College Hospital	Zhao, Haitao
	Fujian Provincial Cancer Hospital	Yu, Wenchang
	Tianjin Medical University Cancer Institute & Hospital	Song, Tianqiang
	The Third Xiangya Hospital of Central South University	Cao, Ke
	Renji Hospital Shanghai Jiaotong University School of Medicine	Mao, Yimin
Fudan University Shanghai Cancer Center	Wang, Lu	
Guangdong Provincial People's Hospital	Chen, Xiaoming	
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	CHU Clermont-Ferrand - Site Estaing	Pezet, Denis (current) Petorin, Caroline (former)
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	Medizinische Hochschule Hannover	Vogel, Arndt
	Krankenhaus Nordwest	Goetze, Thorsten
	Universitaetsklinikum Ulm	Seufferlin, Thomas
	Universitaetsklinikum Hamburg - Eppendorf	Schulze, Kornelius
	Universitaetsklinikum Berlin CCM	Pelzer, Uwe
	Universitaetsklinikum Magdeburg A.o.R.	Venerito, Marino
	Universitaetsklinikum Essen	Kasper-Virchow, Stefan
	Universitaetsklinikum Koeln	Waldschmidt, Dirk Thomas
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	Queen Elizabeth Hospital	Ho, Wang Kwong (current) Lam, Ho Ching (former)
	Prince of Wales Hospital	Chang, Stephan Lam
	Princess Margaret Hospital	Cheng, Ashley
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	Tallaght University Hospital	Kelleher, Fergal
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	Kyorin University Hospital	Mizutani, Tomonori (current) Furuse, Junji (former)
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	Kanagawa Cancer Center	Ueno, Makoto
	Aichi Cancer Center Hospital	Mizuno, Nobumasa
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	The Cancer Institute Hospital of JFCR	Ozaka, Masato
	Kyoto University Hospital	Kanai, Masahi
	Osaka University Hospital	Satho, Taroh
Kagawa University Hospital	Tsuji, Akihito	
Malaysia	Kobe City Medical Center General Hospital	Yasui, Hisateru
	Institute Kanser Negara - National Cancer Institute	Wong, Yoke Fui (current) Tan, Chih Kiang (former)
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	University Malaya Medical Centre	Wan Isahk, Wan Zamaniah
	Pantai Hospital Kuala Lumpur	Low, John
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	AMC	Klumpen, Heinz
	UMCG	de Groot, D.J.A.
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Republic of Korea	Samsung Medical Center	Park, Joon Oh
	Korea University Guro Hospital	Oh, Sang Cheul

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	Chonnam National University Hwasun Hospital	Hwang, Juneul
	Ajou University Hospital, Clinical Research Center	Lee, Hyun Woo
	The Catholic University of Korea, Seoul St. Mary's Hospital	Lee, Myung Ah
	Chungnam National University Hospital	Ryu, Hyewon
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	Hospital General Universitari Vall d'Hebron	Macarulla Mercade, Teresa (current) Verdaguer Mata, Helena (former)
	Hospital General Universitario Gregorio Maranon	Munoz Martin, Andres Jesús
	Hospital Universitario General de Asturias	Jimenez Fonseca, Paula
Taiwan	Hospital Universitario HM Sanchinarro	Cubillo Gracian, Antonio
	Chang Gung Medical Foundation, Linkou	Chen, Jen-Shi
	National Taiwan University Hospital	Hsu, Chiun
	Taipei Veterans General Hospital	Chen, Ming-Huang
	China Medical University Hospital	Bai, Li-Yuan
	National Cheng Kung University Hospital	Yen, Chia-Jui
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	Srinagarind Hospital	Sookprasert, Aumkhae
	Udon Thani Cancer Hospital	Butthongkomvong, Kritiya
	Maharaj Nakorn Chiang Mai Hospital	Suksombooncharoen, Thatthan
	Sriraj Hospital	Soparattanapaisarn, Nopadol
	Ramathibodi Hospital	Ngamphaiboon, Nuttapong
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	Hacettepe University Faculty of Medicine	Yalcin, Suayib
	Baskent University Adana Training Hospital	Kose, Fatih (current) Ozyilkan, Ozgur (former)
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	Inonu Üniversitesi Medical Fakültesi	Harputluoglu, Hakan
	Izmir Medical Park Hospital Department of Medical Oncology	Arslan, Cagatay
	Istanbul Üniversitesi Cerrahpasa Tıp Fakültesi	Ozguroglu, Mustafa
	Belfast City Hospital	Eatock, Martin
	University Hospital Coventry and Warwickshire NHS Trust	Scott-Brown, Martin
Royal Free London NHS Foundation Trust	Gillmore, Roopinder	
Imperial College Healthcare NHS Trust - Hammersmith Hospital	Wasan, Harpeet	
Royal Marsden Hospital (Sutton)	Starling, Naureen	
Royal Marsden Hospital (Chelsea)	Starling, Naureen	
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	University of California Los Angeles - Santa Monica	Finn, Richard
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	Blue Ridge Cancer Care	Kochenderfer, Mark
	Laura and Isaac Perlmutter Cancer Center at NYU Langone Health	Beri, Nina
	Charleston Oncology	Lingerfelt, Brian
	OHSU Center for Health & Healing	Lopez, Charles
	Northwest Georgia Oncology Centers PC	McCune, Steven
	Saint Francis Health System	Yang, Xuezhong
	Yale University	Stein, Stacey
	University of Oklahoma - Stephenson Oklahoma Cancer Center	Hatoum, Hassan
	Decatur Memorial Hospital	Wade, James
	Hartford Hospital	Elias, Rawad

Figure S1. Multiplicity diagram for alpha re-allocation. The initial alpha allocated to each hypothesis is shown under the individual hypotheses. The weights for reallocation should superiority be demonstrated for a hypothesis are shown in the boxes on the lines connecting individual hypotheses.

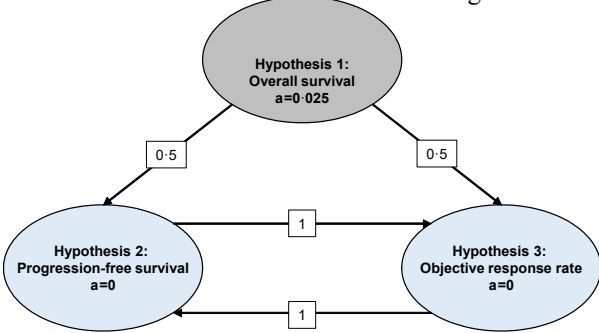
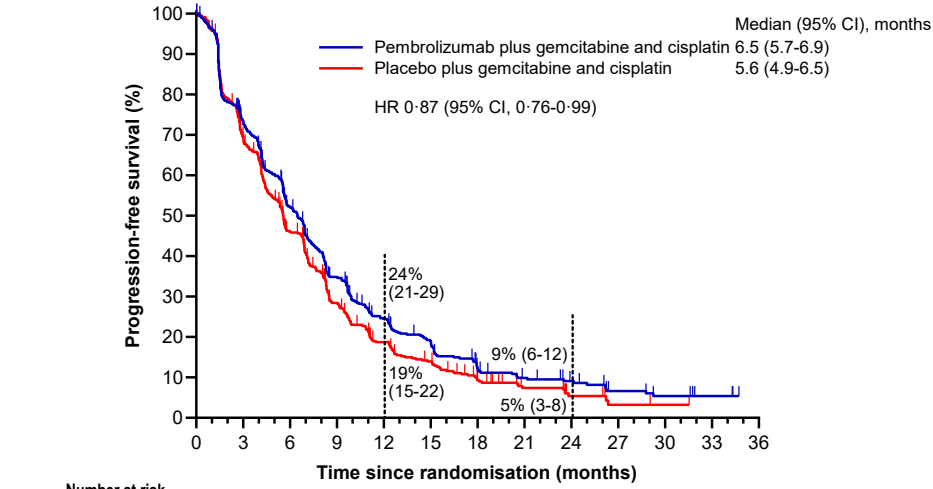


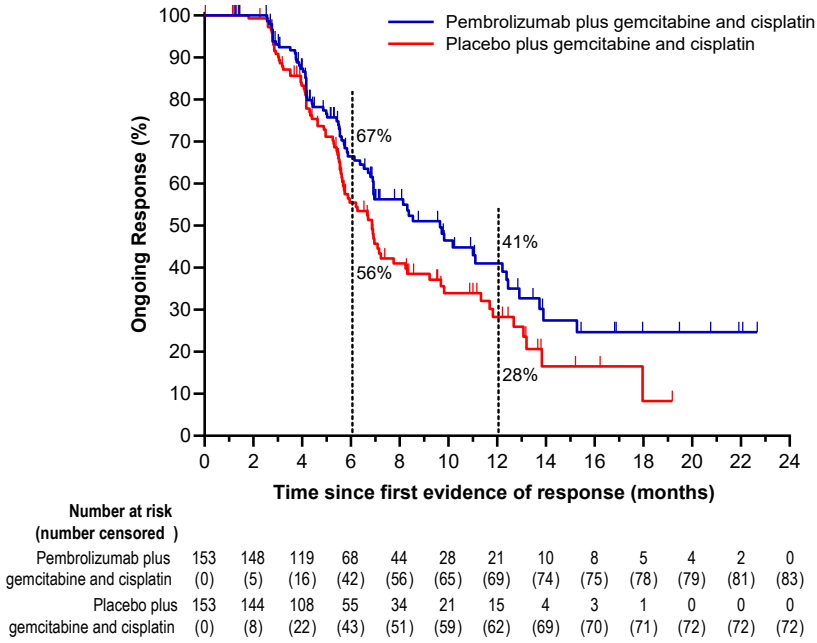
Figure S2. Kaplan-Meier estimates of progression-free survival assessed per masked independent central review in the intention-to-treat population at the final analysis. Tick marks indicate censored data.



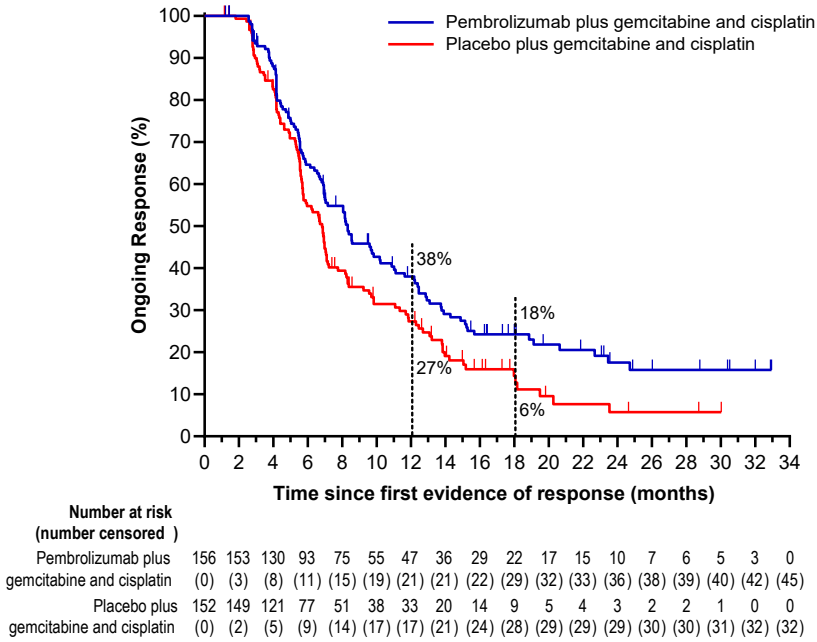
	Number at risk (number censored)												
Pembrolizumab plus gemcitabine and cisplatin	533 (0)	368 (27)	245 (47)	156 (56)	99 (68)	71 (75)	41 (81)	29 (85)	20 (92)	11 (96)	7 (98)	3 (102)	0 (105)
Placebo plus gemcitabine and cisplatin	536 (0)	353 (23)	222 (37)	128 (49)	76 (59)	54 (62)	31 (68)	17 (77)	8 (82)	3 (85)	2 (86)	0 (88)	0 (88)

Figure S3. Kaplan-Meier analyses of duration of response assessed per masked independent central review in the intention-to-treat population. Tick marks indicate censored data.

(A) First interim analysis



(B) Final analysis



1 **Table S1. Central laboratories used in KEYNOTE-966.**

Laboratory Assessment	Laboratory Name and Location	Supported Regions
PD-L1 CPS	NeoGenomics Laboratories, Inc., Aliso Viejo, CA, USA	Argentina, Australia, Belgium, Brazil, Canada, Chile, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Malaysia, Netherlands, New Zealand, Republic of Korea, Spain, Taiwan, Thailand, Türkiye, United Kingdom, USA
	Labcorp Pharmaceutical Research and Development (Shanghai) Co., Limited, Shanghai, China	China
MSI status	Almac Diagnostics, LLC, Craigavon, United Kingdom	Argentina, Australia, Belgium, Brazil, Canada, Chile, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Malaysia, Netherlands, New Zealand, Republic of Korea, Spain, Taiwan, Thailand, Türkiye, United Kingdom, USA
	Q2 Solutions (Beijing) Co., Ltd., Beijing, China	China
HBV and HCV*	PPD Laboratories, Highland Heights, KY, USA	Argentina, Brazil, Canada, Chile, USA
	PPD Laboratories, Zaventem, Belgium	Belgium, France, Germany, Ireland, Israel, Italy, Netherlands, Spain, Türkiye, United Kingdom
	PPD Laboratories, Singapore	Australia, Hong Kong, Japan, Malaysia, New Zealand, Republic of Korea, Taiwan, Thailand
	Labcorp Pharmaceutical Research and Development (Shanghai) Co., Limited, Shanghai, China	China

2 HBV=hepatitis B virus. HCV=hepatitis C virus. MSI=microsatellite. PD-L1 CPS=programmed cell death ligand 1 combined positive score. *HBV and HCV
3 status were tested locally in 13 participants screened for eligibility due to limitations related to the COVID-19 pandemic.
4
5
6

7 **Table S2. Censoring rules for overall survival, progression-free survival, and duration of response.**

Overall survival	Censoring rule
No death date	Censored on the date last known to be alive
Progression-free survival	Date of progression or censoring
PD or death documented after ≤ 1 missed disease assessment and before new anticancer therapy, if any	Progressed at date of documented PD or death
Death or progression immediately after ≥ 2 consecutive missed disease assessments or after new anticancer therapy, if any	Censored at last disease assessment prior to the earlier date of ≥ 2 consecutive missed disease assessments and new anticancer therapy, if any
No PD, no death, and no new anticancer treatment	Censored at last disease assessment
No PD and no death, but new anticancer treatment is initiated	Censored at last disease assessment before new anticancer treatment
Duration of response	Date of progression or censoring
No progression, no death, and no new anticancer therapy is initiated	Censored at last adequate disease assessment
No progression, no death, but new anticancer therapy is initiated	Censored at last adequate disease assessment before new anticancer therapy initiated
Death or progression immediately after ≥ 2 consecutive missed disease assessments or after new anticancer therapy, if any	Censored at earlier date of last adequate disease assessment prior to ≥ 2 missed adequate disease assessments and new anticancer therapy, if any
Death or progression after ≤ 1 missed disease assessment and before new anticancer therapy, if any	Event at date of documented PD or death

8 A missed disease assessment includes any assessment that is not obtained or is considered inadequate for evaluation of response. PD=progressive disease.

9 **Table S3. Number of cycles administered for each component of study treatment in treated participants at the final analysis**

	Pembrolizumab plus gemcitabine and cisplatin (n=529)			Placebo plus gemcitabine and cisplatin (n=534)		
	Pembrolizumab	Gemcitabine	Cisplatin	Placebo	Gemcitabine	Cisplatin
Median (IQR)	9·0 (4·0-15·0)	8·0 (4·0-13·0)	7·0 (4·0-8·0)	8·0 (4·0-14·0)	8·0 (4·0-12·0)	7·0 (4·0-8·0)
≥1	529 (100%)	529 (100%)	527 (<100%)	534 (100%)	534 (100%)	534 (100%)
≥2	490 (93%)	492 (93%)	486 (92%)	498 (93%)	499 (93%)	499 (93%)
≥3	458 (87%)	460 (87%)	450 (85%)	462 (87%)	467 (87%)	464 (87%)
≥4	422 (80%)	426 (81%)	417 (79%)	419 (78%)	420 (79%)	415 (78%)
≥5	388 (73%)	392 (74%)	381 (72%)	377 (71%)	377 (71%)	372 (70%)
≥6	359 (68%)	359 (68%)	346 (65%)	354 (66%)	356 (67%)	347 (65%)
≥7	319 (60%)	315 (60%)	294 (56%)	319 (60%)	313 (59%)	299 (56%)
≥8	302 (57%)	289 (55%)	257 (49%)	297 (56%)	285 (53%)	257 (48%)
≥9	273 (52%)	229 (43%)	1 (<1%)	254 (48%)	209 (39%)	4 (1%)
≥10	248 (47%)	209 (40%)	1 (<1%)	223 (42%)	184 (34%)	2 (<1%)
≥12	206 (39%)	171 (32%)	0	175 (33%)	143 (27%)	0
≥14	156 (29%)	128 (24%)	0	135 (25%)	102 (19%)	0
≥16	129 (24%)	102 (19%)	0	112 (21%)	85 (16%)	0
≥18	101 (19%)	81 (15%)	0	93 (17%)	74 (14%)	0
≥20	84 (16%)	61 (12%)	0	82 (15%)	65 (12%)	0
≥22	69 (13%)	48 (9%)	0	65 (12%)	49 (9%)	0
≥24	64 (12%)	43 (8%)	0	51 (10%)	39 (7%)	0
≥26	55 (10%)	35 (7%)	0	45 (8%)	34 (6%)	0
≥28	41 (8%)	25 (5%)	0	31 (6%)	26 (5%)	0
≥30	35 (7%)	22 (4%)	0	26 (5%)	22 (4%)	0
≥32	28 (5%)	17 (3%)	0	21 (4%)	19 (4%)	0
≥34	24 (5%)	13 (2%)	0	16 (3%)	11 (2%)	0
≥35	20 (4%)	10 (2%)	0	13 (2%)	9 (2%)	0

10

11 **Table S4. Summary of subsequent anticancer therapy in the intention-to-treat population at the final analysis**

	Pembrolizumab plus chemotherapy (n=533)	Placebo plus chemotherapy (n=536)
Any subsequent anticancer therapy*	253 (47%)	261 (49%)
Chemotherapy	230 (43%)	230 (43%)
Immune checkpoint inhibitor	26 (5%)	38 (7%)
Targeted therapy	6 (1%)	18 (3%)
Other	43 (8%)	50 (9%)

12 Data are n (%). *Participants may have received ≥ 1 subsequent anticancer therapy.

13

14 **Table S5. Summary of response in the intention-to-treat population at the final analysis**

	Pembrolizumab plus gemcitabine and cisplatin (n=533)	Placebo plus gemcitabine and cisplatin (n=536)
Objective response rate	156 (29% [25-33])	152 (28% [25-32])
Disease control rate	399 (75 [71-79])	405 (76% [72-79])
Best overall response		
Complete response	14 (3%)	9 (2%)
Partial response	142 (27%)	143 (27%)
Stable disease*	243 (46%)	253 (47%)
Progressive disease	104 (20%)	97 (18%)
Not evaluable†	8 (2%)	11 (2%)
Not assessed‡	22 (4%)	23 (4%)
Time to response, months	2·8 (1·5-4·2)	2·8 (1·5-4·2)
Duration of response,§ months	8·3 (6·9-10·2)	6·8 (5·7-7·1)
Extended duration of response§		
≥3 months	94%	90%
≥6 months	65%	55%
≥9 months	46%	36%
≥12 months	38%	27%
≥15 months	28%	18%
≥18 months	24%	14%
≥21 months	21%	8%
≥24 months	18%	6%

15 Data are n (% [95% CI]), n (%), median (IQR) (for time to response), median (95% CI) (for duration of response), or %. *Stable disease includes participants
 16 with stable disease, non-complete response or non-progressive disease, and no evidence of disease. †Not evaluable includes participants whose post-baseline
 17 imaging assessments were not evaluable for best overall response. ‡Not assessed includes participants for whom no post-baseline imaging assessments were
 18 available. §Estimated using the Kaplan-Meier method.

19 **Table S6. Treatment-related adverse events that occurred in $\geq 5\%$ of participants either treatment group in the safety population at the final analysis**

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)				Placebo plus gemcitabine and cisplatin group (n=534)			
	Grade 1-2	Grade 3	Grade 4	Grade 5	Grade 1-2	Grade 3	Grade 4	Grade 5
Any event	116 (22%)	248 (47%)	121 (23%)	8 (2%)	130 (24%)	255 (48%)	112 (21%)	3 (1%)
Decreased neutrophil count	74 (14%)	158 (30%)	89 (17%)	0	74 (14%)	167 (31%)	79 (15%)	0
Anaemia	155 (29%)	122 (23%)	1 (<1%)	0	138 (26%)	127 (24%)	4 (1%)	0
Decreased platelet count	114 (22%)	55 (10%)	30 (6%)	0	98 (18%)	66 (12%)	33 (6%)	0
Nausea	188 (36%)	7 (1%)	0	0	210 (39%)	9 (2%)	0	0
Fatigue	133 (25%)	20 (4%)	1 (<1%)	0	129 (24%)	18 (3%)	0	0
Decreased white blood cell count	78 (15%)	57 (11%)	4 (1%)	0	78 (15%)	43 (8%)	3 (1%)	0
Decreased appetite	96 (18%)	6 (1%)	1 (<1%)	0	98 (18%)	6 (1%)	0	0
Vomiting	79 (15%)	7 (1%)	0	0	97 (18%)	4 (1%)	0	0
Constipation	84 (16%)	1 (<1%)	0	0	73 (14%)	1 (<1%)	0	0
Rash	70 (13%)	3 (1%)	0	0	35 (7%)	2 (<1%)	0	0
Increased alanine aminotransferase	50 (9%)	6 (1%)	0	0	68 (13%)	3 (1%)	0	0
Pyrexia	53 (10%)	2 (<1%)	0	0	35 (7%)	0	0	0
Alopecia	53 (10%)	0	0	0	65 (12%)	0	0	0
Diarrhoea	48 (9%)	5 (1%)	0	0	52 (10%)	3 (1%)	0	0
Pruritus	52 (10%)	0	0	0	31 (6%)	0	0	0
Asthenia	44 (8%)	7 (1%)	0	0	66 (12%)	15 (3%)	0	0
Hypomagnesaemia	45 (9%)	4 (1%)	0	0	56 (10%)	5 (1%)	0	0
Increased aspartate aminotransferase	41 (8%)	4 (1%)	0	0	51 (10%)	8 (1%)	1 (<1%)	0
Hypothyroidism	40 (8%)	1 (<1%)	0	0	11 (2%)	0	0	0
Increased blood creatinine	38 (7%)	1 (<1%)	0	0	39 (7%)	0	0	0
Peripheral oedema	31 (6%)	0	0	0	28 (5%)	4 (<1%)	0	0
Malaise	29 (5%)	1 (<1%)	0	0	27 (5%)	0	0	0
Dysgeusia	29 (5%)	0	0	0	26 (5%)	1 (<1%)	0	0
Leukopenia	14 (3%)	9 (2%)	2 (<1%)	0	6 (1%)	5 (1%)	1 (<1%)	0
Mucosal inflammation	22 (4%)	2 (<1%)	0	0	22 (4%)	1 (<1%)	0	0
Peripheral sensory neuropathy	22 (4%)	2 (<1%)	0	0	21 (4%)	0	0	0
Decreased lymphocyte count	14 (3%)	5 (1%)	1 (<1%)	0	17 (3%)	9 (2%)	1 (<1%)	0
Stomatitis	16 (3%)	3 (1%)	0	0	25 (5%)	2 (<1%)	0	0

20 Data are n (%).

21

Table S7. Adverse events that led to death in the as-treated population at the final analysis

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)			Placebo plus gemcitabine and cisplatin group (n=534)		
	Any cause	Treatment related	Immune mediated	Any cause	Treatment related	Immune mediated
Any death	31 (6%)	8 (2%)	1 (<1%)	49 (9%)	3 (1%)	0
Pneumonia	4 (1%)	0	0	0	0	0
Death	3 (1%)	0	0	5 (1%)	0	0
Sepsis	3 (1%)	0	0	6 (1%)	1 (<1%)	0
Biliary tract infection	2 (<1%)	0	0	0	0	0
Euthanasia	2 (<1%)	0	0	1 (<1%)	0	0
Abdominal abscess	1 (<1%)	1 (<1%)	0	0	0	0
Abdominal infection	1 (<1%)	0	0	0	0	0
COVID-19	1 (<1%)	0	0	4 (1%)	0	0
Cardiac arrest	1 (<1%)	0	0	0	0	0
Cholangitis	1 (<1%)	1 (<1%)	0	0	0	0
Fungal sepsis	1 (<1%)	0	0	0	0	0
Gastrointestinal haemorrhage	1 (<1%)	0	0	0	0	0
Haemorrhagic shock	1 (<1%)	0	0	0	0	0
Lower respiratory tract infection	1 (<1%)	1 (<1%)	0	0	0	0
Malignant neoplasm progression	1 (<1%)	1 (<1%)	0	0	0	0
Myocardial infarction	1 (<1%)	1 (<1%)	0	0	0	0
Pneumocystis jirovecii pneumonia	1 (<1%)	0	0	0	0	0
Pneumonia aspiration	1 (<1%)	0	0	0	0	0
Pneumonia viral	1 (<1%)	1 (<1%)	0	0	0	0
Pneumonitis	1 (<1%)	1 (<1%)	1 (<1%)	0	0	0
Pulmonary embolism	1 (<1%)	0	0	3 (1%)	0	0
Septic shock	1 (<1%)	1 (<1%)	0	1 (<1%)	0	0
Acute kidney injury	0	0	0	2 (<1%)	0	0
Acute myocardial infection	0	0	0	1 (<1%)	0	0
Biliary sepsis	0	0	0	1 (<1%)	0	0
COVID-19 pneumonia	0	0	0	2 (<1%)	0	0
Cerebral haemorrhage	0	0	0	1 (<1%)	0	0
Cerebral infarction	0	0	0	3 (1%)	0	0
Cerebral venous sinus thrombosis	0	0	0	1 (<1%)	0	0
Cholangitis infective	0	0	0	1 (<1%)	0	0
Cholecystitis	0	0	0	1 (<1%)	0	0
Diarrhoea	0	0	0	1 (<1%)	0	0
Hepatic infection	0	0	0	1 (<1%)	0	0
Hepatorenal syndrome	0	0	0	1 (<1%)	1 (<1%)	0
Ileus	0	0	0	1 (<1%)	0	0
Liver abscess	0	0	0	2 (<1%)	0	0

Lung abscess	0	0	0	1 (<1%)	0	0
Oesophageal varices haemorrhage	0	0	0	1 (<1%)	0	0
Pneumococcal sepsis	0	0	0	1 (<1%)	0	0
Pneumonia acinebacter	0	0	0	1 (<1%)	0	0
Pneumonia bacterial	0	0	0	1 (<1%)	0	0
Post procedural complication	0	0	0	1 (<1%)	0	0
Respiratory failure	0	0	0	1 (<1%)	0	0
Spontaneous bacteria peritonitis	0	0	0	1 (<1%)	0	0
Upper gastrointestinal haemorrhage	0	0	0	2 (<1%)	1 (<1%)	0

23 Data are n (%). Treatment relatedness was determined by the investigator. Potentially immune-mediated adverse events and infusion reactions were based on a
24 list of terms prepared by the sponsor and were considered regardless of attribution to trial treatment by the investigator; in addition to the specific preferred terms
25 listed, related terms were included.
26

27 **Table S8. Potentially immune-mediated adverse events and infusion reactions in the as-treated population at the final analysis**

	Pembrolizumab plus gemcitabine and cisplatin group (n=529)				Placebo plus gemcitabine and cisplatin group (n=534)			
	Grade 1-2	Grade 3	Grade 4	Grade 5	Grade 1-2	Grade 3	Grade 4	Grade 5
Any event	79 (15%)	35 (7%)	2 (<1%)	1 (<1%)	48 (9%)	18 (3%)	3 (1%)	0
Hypothyroidism	45 (9%)	1 (<1%)	0	0	14 (3%)	0	0	0
Pneumonitis	20 (4%)	5 (1%)	0	1 (<1%)	9 (2%)	0	1 (<1%)	0
Hyperthyroidism	18 (3%)	1 (<1%)	0	0	10 (2%)	0	0	0
Colitis	4 (1%)	4 (1%)	1 (<1%)	0	4 (1%)	2 (<1%)	0	0
Severe skin reactions	0	10 (2%)	0	0	0	3 (1%)	0	0
Hepatitis	4 (1%)	5 (1%)	0	0	0	6 (1%)	1 (<1%)	0
Infusion reactions	6 (1%)	2 (<1%)	0	0	6 (1%)	0	0	0
Pancreatitis	1 (<1%)	3 (1%)	0	0	2 (<1%)	3 (1%)	1 (<1%)	0
Adrenal insufficiency	2 (<1%)	1 (<1%)	0	0	1 (<1%)	1 (<1%)	0	0
Thyroiditis	3 (1%)	0	0	0	0	0	0	0
Encephalitis	0	2 (<1%)	0	0	0	0	0	0
Hypophysitis	1 (<1%)	1 (<1%)	0	0	1 (<1%)	1 (<1%)	0	0
Nephritis	2 (<1%)	0	0	0	1 (<1%)	0	0	0
Vasculitis	2 (<1%)	0	0	0	1 (<1%)	0	0	0
Myasthenic syndrome	0	0	1 (<1%)	0	0	1 (<1%)	0	0
Myocarditis	0	0	1 (<1%)	0	0	1 (<1%)	0	0
Myositis	1 (<1%)	0	0	0	0	0	0	0
Hypoparathyroidism	0	0	0	0	1 (<1%)	0	0	0
Uveitis	0	0	0	0	2 (<1%)	0	0	0

28 Data are n (%). Potentially immune-mediated adverse events and infusion reactions were based on a list of terms prepared by the sponsor and were considered
 29 regardless of attribution to trial treatment by the investigator; in addition to the specific preferred terms listed, related terms were included.
 30

31 **Table S9. Use of corticosteroids for the treatment of potentially immune-mediated adverse events and infusion reactions in participants in the safety**
 32 **population who experienced an event at the final analysis**

	Pembrolizumab plus gemcitabine and cisplatin group			Placebo plus gemcitabine and cisplatin group		
	High starting dose*	Low starting dose†	Not treated	High starting dose*	Low starting dose†	Not treated
Adrenal insufficiency	1/3 (33%)	1/3 (33%)	1/3 (33%)	0	1/2 (50%)	1/2 (50%)
Colitis	5/9 (56%)	1/9 (11%)	3/9 (33%)	4/6 (67%)	0	2/6 (33%)
Encephalitis	2/2 (100%)	0	0	0	0	0
Hepatitis	5/9 (57%)	2/9 (22%)	2/9 (22%)	7/7 (100%)	0	0
Hyperthyroidism	1/19 (5%)	0	18/19 (95%)	0	0	10/10 (100%)
Hypoparathyroidism	0	0	0	0	0	1/1 (100%)
Hypophysitis	0	1/2 (50%)	1/2 (50%)	1/2 (50%)	1/2 (50%)	0
Hypothyroidism	1/46 (2%)	0	45/46 (98%)	0	0	14/14 (100%)
Infusion reactions	4/8 (50%)	1/8 (13%)	3/8 (38%)	2/6 (33%)	1/6 (17%)	3/6 (50%)
Myasthenic syndrome	1/1 (100%)	0	0	1/1 (100%)	0	0
Myocarditis	1/1 (100%)	0	0	0	1/1 (100%)	0
Myositis	0	0	1/1 (100%)	0	0	0
Nephritis	1/2 (50%)	1/2 (50%)	0	1/1 (100%)	0	0
Pancreatitis	2/4 (50%)	0	2/4 (50%)	0	0	6/6 (100%)
Pneumonitis	11/26 (42%)	6/26 (23%)	9/26 (35%)	4/10 (40%)	1/10 (10%)	5/10 (50%)
Severe skin reactions	4/10 (40%)	2/10 (20%)	4/10 (40%)	1/3 (33%)	1/3 (33%)	1/3 (33%)
Thyroiditis	0	0	3/3 (100%)	0	0	0
Uveitis	0	0	0	0	0	2/2 (100%)
Vasculitis	0	0	2/2 (100%)	0	0	1/1 (100%)

33 Data are no. of participants treated with corticosteroids/no. of participants with the event (%). *A high starting dose of corticosteroids was defined as ≥ 40 mg/day
 34 prednisone or equivalent. †A low starting dose of corticosteroids was defined as < 40 mg/day prednisone or equivalent.
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