

Background

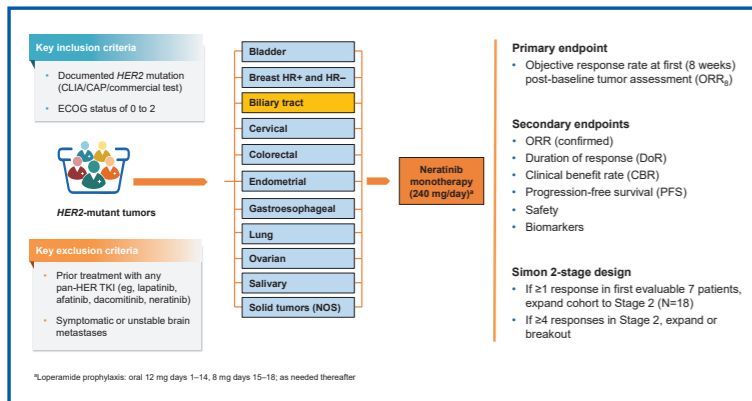
- HER2* mutations are infrequent genomic events in biliary tract cancers (BTCs) and are associated with poor overall survival (OS) in patients with metastatic disease.¹
- HER2* overexpression is associated with an increased risk of disease recurrence in patients with resected BTC.² There is limited data on targeting *HER2* in BTC harboring activating somatic *HER2* mutations.
- Neratinib, an irreversible, pan-*HER*, oral tyrosine kinase inhibitor (TKI), interferes with constitutive receptor kinase activation³⁻⁵ and has demonstrated activity in several *HER2*-mutant solid tumors.⁶⁻⁸
- SUMMIT is an open-label, single-arm, multi-cohort, phase 2, 'basket' trial of neratinib in patients with solid tumours harbouring oncogenic *HER2* somatic mutations (NCT01953926).
- In the initial study report from SUMMIT, the antitumor activity of neratinib appeared to be dependent on both histology and mutation. One of the first seven patients enrolled in the *HER2*-mutant BTC cohort achieved a partial response (PR), meeting Simon two-stage criteria for cohort expansion.⁸
- Here, we report the final results of the expanded *HER2*-mutant BTC cohort in SUMMIT.

Methods

Study design

- The design of the SUMMIT multi-histology 'basket' study is shown in Figure 1.

Figure 1. SUMMIT multi-histology 'basket' study design: Neratinib monotherapy cohorts



Genomic analysis

- Archival or pre-treatment formalin-fixed, paraffin-embedded (FFPE) tumor tissue was required for study entry. Plasma was collected before treatment, on treatment (every other cycle), and at treatment discontinuation.
- Tumor DNA was extracted from FFPE tissue or plasma and sequenced using Memorial Sloan Kettering-Integrated Mutation Profiling of Actionable Cancer Targets (MSK-IMPACT)⁹ or MSK-ACCESS.¹⁰
- Custom targeted *HER2* single-gene sequencing was performed in select cases using plasma samples. Somatic alterations were annotated with OncoKB (version date December 24, 2021).

Statistics

- Baseline characteristics, activity, and safety were summarised in the safety analysis set (all patients receiving at least one neratinib dose).
- The Clopper-Pearson method was used to calculate ORR and CBR 95% confidence intervals (CIs). Kaplan-Meier methodology was used to determine PFS estimates with 95% CIs.
- All statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA) or the survival package (version 3.1-12) from R (version 4.0.2).

Results

Table 1. Baseline demographics

	<i>HER2</i> -mutant biliary cohort (n=25)
Median age, years (range)	65 (49–78)
Female sex, n (%)	13 (52)
ECOG performance status, n (%)	0 / 1 / 2
	6 (24) / 17 (68) / 2 (8)
Tumor site, n (%)	
Cholangiocarcinoma	11 (44)
Intrahepatic	6 (24)
Extrahepatic	5 (20)
Gallbladder	10 (40)
Ampulla of Vater	4 (16)
M1 stage at enrollment, n (%)	25 (100)
Patients with prior surgery, n (%)	16 (64)
Patients with prior radiation, n (%)	5 (20)
Median no. of prior systemic regimens (range)	2 (0–7)
Prior systemic therapy, n (%)	
Gemcitabine-based	24 (96)
Platinum-based	23 (92)
Fluoropyrimidine-based	18 (72)
None	1 (4)

ECOG = Eastern Cooperative Oncology Group. Data cut-off: Jan 22, 2021.

Table 2. Efficacy summary

Efficacy endpoint*	<i>HER2</i> -mutant biliary cohort (n=25)
Objective response at first assessment (Week 8), n/N, %	2/18 (11.1)
Objective response (confirmed), ^b n	4
CR	0
PR	4
Objective response rate, % (95% CI)	16.0 (4.5–36.1)
Best overall response, n (%)	5 (20.0)
DOR for each responder, months	3.0, 3.6, 3.7, 4.7
Clinical benefit, ^c n	7
CR	0
PR	4
SD ≥16 weeks	3
Clinical benefit rate, % (95% CI)	28.0 (12.1–49.4)
Median PFS, ^d months (95% CI)	2.8 (1.1–3.7)
Median OS, months (95% CI)	5.4 (3.7–11.7)

*Response is based on investigator tumor assessments per RECIST v1.1; ^bObjective response rate is defined as either a complete or partial response that is confirmed no less than 4 weeks after the criteria for response are initially met; ^cClinical benefit rate is defined as confirmed CR or PR or SD for at least 16 weeks (within ± 7-day visit window); ^dKaplan-Meier analysis. CR = complete response; DOR = duration of response; PFS = progression-free survival; PR = partial response; OS = overall survival; SD = stable disease.

Figure 2. Waterfall plot for 19 patients with RECIST-evaluable disease

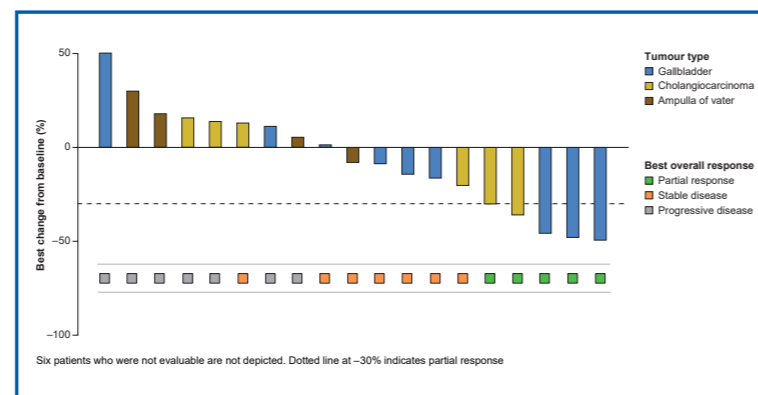


Figure 3. Treatment and response assessment

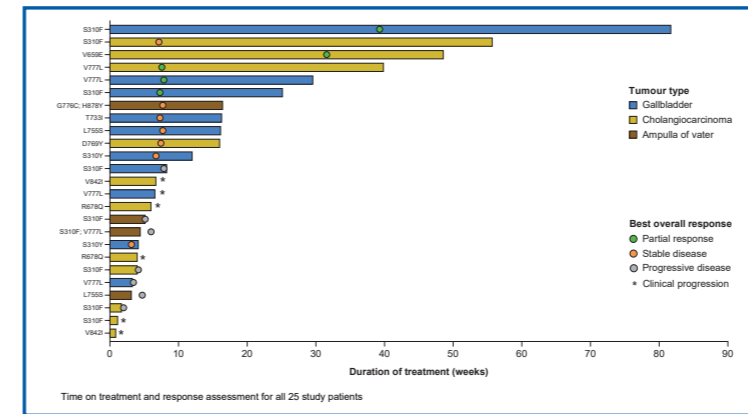


Figure 4. Lollipop diagram of the *HER2* gene annotated with centrally confirmed mutations and tumor responses (n=23)

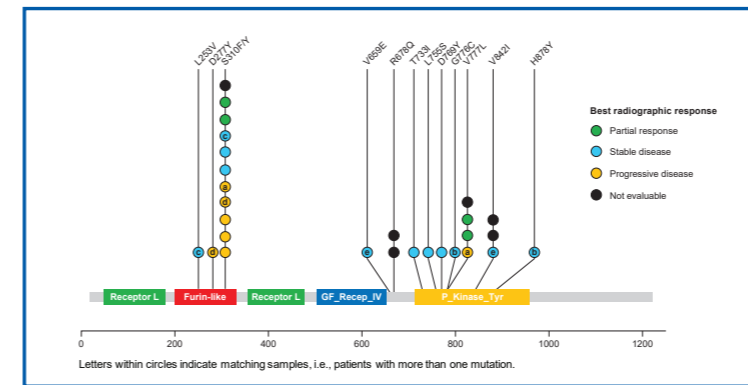


Figure 5. OncoPrint of co-occurring genomic alterations (n=23)

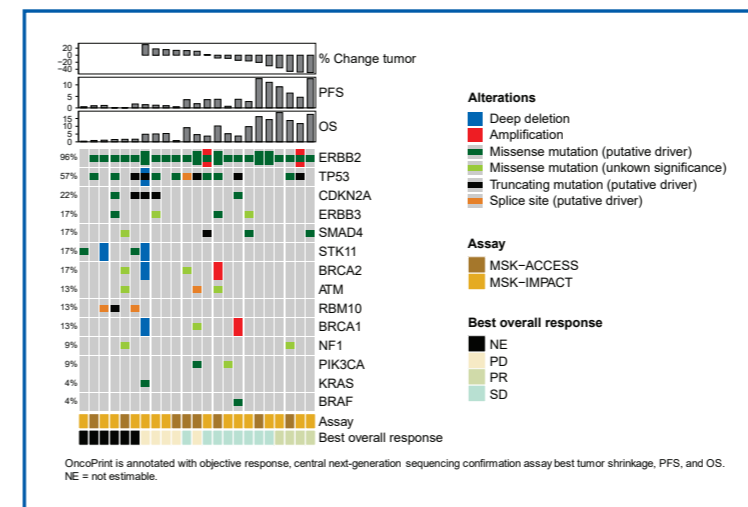


Figure 6. Polyclonal resistance to neratinib in 71-year-old woman with adenosquamous carcinoma of the gallbladder harbouring *HER2*-amplified/*S310F* mutation

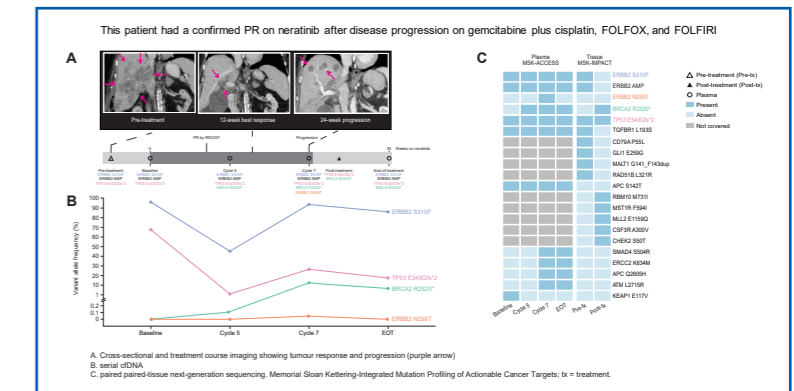


Table 3. Incidence of treatment-emergent adverse events (≥15%)

Adverse event, n (%)	<i>HER2</i> -mutant biliary tract cancer cohort (n=25)		
	All grades	Grade 1 or 2	Grade 3 or 4
Diarrhea*	14 (56)	8 (32)	6 (24)*
Vomiting	12 (48)	11 (44)	1 (4)
Fatigue	10 (40)	10 (40)	0
Nausea	10 (40)	10 (40)	0
Abdominal pain	8 (32)	6 (24)	2 (8)
Decreased appetite	7 (28)	7 (28)	0
Constipation	6 (24)	6 (24)	0
Aspartate aminotransferase increased	4 (16)	3 (12)	1 (4)
Dehydration	4 (16)	2 (8)	2 (8)
Dizziness	4 (16)	4 (16)	0
Dry mouth	4 (16)	4 (16)	0
Pyrexia	4 (16)	4 (16)	0

All 25 patients had at least one adverse event (AE); 16 (64%) had one or more serious AEs, two (8%) had serious treatment-related AEs, and five (20%) had treatment-emergent AEs and/or clinical progression leading to treatment discontinuation. *Diarrhea was the most common AE. Loperamide prophylaxis was used as follows: oral 12 mg days 1–14, 8 mg days 15–18; as needed thereafter; †There was no grade 4 diarrhea. Two patients had a grade 5 AE: one died because of general deterioration and one because of sepsis.

Summary and conclusions

- The SUMMIT trial has reported encouraging activity of neratinib in patients with *HER2*-mutant biliary cancers, with especially promising tumor responses in patients with cholangiocarcinoma or gallbladder cancer.
- The major observed toxicities were manageable gastrointestinal AEs and were consistent with expectations.
- Limitations of the study are the small sample size and inclusion of patients with poor ECOG performance status, leading to a high proportion of non-evaluable patients.
- In the *HER2*-mutant breast and *HER2*-mutant lung cohorts of SUMMIT,^{11,12} addition of trastuzumab to neratinib prolonged and deepened responses; the same approach should be explored for *HER2*-mutant biliary cancer.

References

- Valle et al. N Engl J Med 2010;362:1273–81.
- Vivaldi C, et al. Oncologist 2020;25:886–93.
- Bose R, et al. Cancer Discov 2013;3:224–37.
- Greulich H, et al. Proc Natl Acad Sci USA 2012;109:14476–81.
- Zammataro L, et al. Proc Natl Acad Sci USA 2019;116:22730–6.
- Martin M, et al. Lancet Oncol 2017;18:1688–700.
- Saura C, et al. J. Clin. Oncol 2020;38:3138–49.
- Hyman DM, et al. Nature 2018;554:189–94.
- Cheng DT, et al. J Mol Diagn 2015;17:251–64.
- Rose Brannon A, et al. Nat Commun 2021;12:3770.
- Smyth LM, et al. Cancer Discov 2020;10:198–231.
- Boni V, et al. 2020 World Conference on Lung Cancer Singapore (2021).

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