

Integrated Population Pharmacokinetic Analysis of Conjugated and Unconjugated Payload of Patritumab Deruxtecan in Cancer Patients

Mark Lee¹, Shelly Wang², Rena Byrne², Rujuta Joshi¹, Malaz Abutarifi¹, Tushar Garimella¹, Li Li¹

¹. Daiichi Sankyo, Inc, Basking Ridge, NJ, USA; ². Metrum Research Group, Tariffville, CT, USA

OBJECTIVES

- Develop a PopPK model to characterize the PK of anti-HER3-ac-DXd and DXd.
- Quantify the effects of baseline demographic, laboratory, and disease characteristics on PK in cancer patients.

CONCLUSIONS

- The integrated PopPK model characterized the PK of two analytes in cancer patients treated with Patritumab deruxtecan (HER3-DXd, U3-1402).
- Covariates influencing exposures were identified. Lower baseline eGFR and albumin tended to be associated with lower exposure (Cavgs) anti-HER3-ac-DXd but were still within range of 95% CI of the median projected population exposures.
- The availability of the model will allow sparse sampling in future Phase 3 trials while still characterizing the PK profile.
- This evaluation supports the use of derived individual exposure metrics in exposure response evaluation.

INTRODUCTION

Patritumab deruxtecan (HER3-DXd) is a human epidermal growth factor receptor (HER3)-targeting antibody-drug conjugate with a topoisomerase I inhibitor payload (DXd). The drug-to-antibody ratio is approximately 8. HER3-DXd is currently being investigated as an anticancer agent in several phase 1-3 clinical studies in breast cancer (BC) and non-small cell lung cancer (NSCLC) patients.

RESULTS

Table 2. Summary of continuous baseline covariates by study in PPK analysis

Variable	n	Mean	Median	SD	Min / Max
Study U31402-J101					
Age (years)	182	55.6	57.0	12.5	30.0 / 83.0
Weight (kg)	182	56.7	54.0	13.9	35.1 / 110
Body surface area (m ²)	182	1.55	1.53	0.181	1.22 / 2.25
Estimated glomerular filtration (eGFR) (mL/min/1.73m ²)	182	98.4	99.8	17.7	37.8 / 134
Creatinine clearance (mL/min)	182	91.9	89.8	30.1	35.7 / 192
Albumin (g/L)	182	38.2	39.0	5.10	17.0 / 49.0
Baseline SLD (cm)	182	7.81	6.55	4.98	1.00 / 31.0
Baseline H-score	49	157	140	64.8	60.0 / 300
Study U31402-U102					
Age (years)	219	61.7	63.0	9.93	29.0 / 80.0
Weight (kg)	219	64.2	62.0	15.0	32.4 / 113
Body surface area (m ²)	215	1.69	1.66	0.222	1.19 / 2.37
Estimated glomerular filtration (eGFR) (mL/min/1.73m ²)	219	82.1	85.4	18.8	31.9 / 134
Creatinine clearance (mL/min)	213	76.8	75.4	25.9	30.2 / 174
Albumin (g/L)	218	38.7	39.0	4.61	22.0 / 46.0
Baseline SLD (cm)	219	6.31	5.60	3.87	1.00 / 20.5
Baseline H-score	183	155	170	72.3	0.00 / 300

All data

Variable	n	Mean	Median	SD	Min / Max
Age (years)	401	58.9	60.0	11.6	29.0 / 83.0
Weight (kg)	401	60.8	57.4	15.0	32.4 / 113
Body surface area (m ²)	397	1.63	1.59	0.215	1.19 / 2.37
Estimated glomerular filtration (eGFR) (mL/min/1.73m ²)	401	89.5	91.6	20.0	31.9 / 134
Creatinine clearance (mL/min)	395	83.8	80.1	28.9	30.2 / 192
Albumin (g/L)	400	38.5	39.0	4.84	17.0 / 49.0
Baseline SLD (cm)	401	6.99	6.10	4.46	1.00 / 31.0
Baseline H-score	232	155	166	70.6	0.00 / 300

Table 3. Summary of categorical covariates by study in PPK analysis

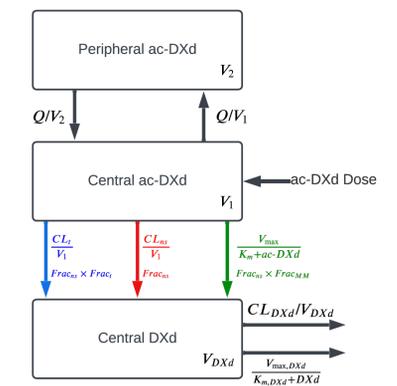
Sex	Study		
	U31402-J101 n = 182	U31402-U102 n = 219	Summary n = 401
Female	182 (100.0)	139 (63.5)	321 (80.0)
Male	0 (0.0)	80 (36.5)	80 (20.0)
Missing	0 (0.0)	0 (0.0)	0 (0.0)
Race			
American Indian or Alaska Native	1 (0.5)	1 (0.5)	2 (0.5)
Asian	142 (78.0)	103 (47.0)	245 (61.1)
Black or African American	4 (2.2)	5 (2.3)	9 (2.2)
Native Hawaiian or Other Pacific Islander	0 (0.0)	2 (0.9)	2 (0.5)
White	34 (18.7)	95 (43.4)	129 (32.2)
Multiple	1 (0.5)	13 (5.9)	14 (3.5)
Other	0 (0.0)	0 (0.0)	0 (0.0)
Hepatic function category (NCI-ODWG)			
Normal	102 (56.0)	186 (84.9)	288 (71.8)
Mild	76 (41.8)	31 (14.2)	107 (26.7)
Moderate	3 (1.6)	0 (0.0)	3 (0.7)
Severe	0 (0.0)	0 (0.0)	0 (0.0)
Missing	1 (0.5)	2 (0.9)	3 (0.7)
Renal function category (CKD-EP)			
Normal	134 (73.6)	87 (39.7)	221 (55.1)
Mild	41 (22.5)	98 (44.7)	139 (34.7)
Moderate	7 (3.8)	34 (15.5)	41 (10.2)
Severe	0 (0.0)	0 (0.0)	0 (0.0)
Missing	0 (0.0)	0 (0.0)	0 (0.0)
ECOG status			
0	132 (72.5)	77 (35.2)	209 (52.1)
1	50 (27.5)	142 (64.8)	192 (47.9)
2	0 (0.0)	0 (0.0)	0 (0.0)
Missing	0 (0.0)	0 (0.0)	0 (0.0)
Tumor type			
Breast cancer	182 (100.0)	0 (0.0)	182 (45.4)
NSCLC	0 (0.0)	219 (100.0)	219 (54.6)
Others	0 (0.0)	0 (0.0)	0 (0.0)

Summary is count (percent)
n: number of records summarized; Source code: ppk-edata-tables.R; Source file: ppk-cat.tex

Model Schematic

- The integrated model structure consisted of 3 compartments
- The PK of anti-HER3-ac-DXd was described by a two-compartment model with three elimination pathways:
 - CL_T = Transient and linear, time-dependent clearance
 - CL_{ns} = Non-specific time-dependent linear clearance
 - CL_{MM} = Non-linear Michaelis-Menten clearance
- DXd formation was described by Frac_{ns}, Fract and Frac_{mm} which were the relative fractions of anti-HER3-ac-DXd CL_{ns}, CL_T, and CL_{MM}, respectively.
- DXd was described by a one-compartment model with two clearance pathways:
 - CL_{DXd} = linear DXd clearance
 - CL_{MM,DXd} = non-linear DXd, Michaelis-Menten clearance

Figure 1. Model Schematic



METHODS

The PopPK analysis included data from 2 phase III studies in breast cancer and non-small cell lung cancer (U31402-A-J101 and U31402-A-U102, respectively) treated over the dose range of 1.6 to 8.0 mg/kg administered via intravenous infusion across different dosing regimens.

Table 1. Study Summaries

Study	Dosing Regimen	Objectives
U31402-A-J101	Dose Escalation Part: Q3W IV dosing regimens of: 1.6 mg/kg, 3.2 mg/kg, 4.8 mg/kg, 6.4 mg/kg, and 8.0 mg/kg Dose Finding Part: 3 cycles of 4.2 mg/kg every 2 weeks, followed by cycles of 6.4 mg/kg Q3W, or Up-titration regimen of Q3W cycles comprising Cycle 1: 3.2 mg/kg, Cycle 2: 4.8 mg/kg, and Cycle 3 and thereafter: 6.4 mg/kg Dose Expansion Part: 4.8 mg/kg or 6.4 mg/kg Q3W IV	To assess safety and tolerability of U3-1402, to determine the maximum tolerated dose (MTD) of U3-1402 and to determine the recommended dose(s) for expansion (RDEs) of U3-1402 The primary objective for dose expansion part was to assess safety and evaluate efficacy of U3-1402 at the RDEs in subjects with human epidermal growth factor receptor 2 (HER2)-negative and hormone receptor (HR)-positive breast cancer
U31402-A-U102	Dose Escalation Part: 3.2, 4.8, 5.6, or 6.4 mg/kg Q3W IV Dose Expansion Part: 5.6 mg/kg Q3W IV or up-titration regimen of Q3W cycles of Cycle 1: 3.2 mg/kg, Cycle 2: 4.8 mg/kg, and Cycle 3 and thereafter: 6.4 mg/kg	The primary objectives for dose escalation part was to assess the safety and tolerability of U3-1402 in metastatic or unresectable NSCLC (RDEs), and to determine the recommended dose for expansion (RDE) of U3-1402 in metastatic or unresectable EGFRm NSCLC subjects who (a) are T790M mutation-negative after disease progression during treatment with erlotinib, gefitinib, or atatinib or (b) develop disease progression while on osimertinib The primary objective for dose expansion part was to investigate the antitumor activity of U3-1402

Proportions of Total Clearance of anti-HER3-ac-DXd and DXd

- Separate clearance pathways were needed to describe the dynamics of anti-HER3-ac-DXd exposure and can be explained by mechanistic understanding of ADC disposition and elimination:
 - The non-specific clearance (CL_{ns}) pathway was identified as the major clearance pathway and described the mechanism of antibody turnover.
 - The CL_T pathway was used to describe the initial rapid decrease of clearance within the first cycle, when the antibody quickly binds to the receptors.
 - The CL_{MM} clearance pathway mainly affected PK at low anti-HER3-ac-DXd concentrations, when receptors are not saturated, and played a relatively minor role in total elimination of the antibody.
- DXd exposure also required two clearance pathways to describe PK dynamics:
 - CL_{DXd} described the linear clearance portion and CL_{MM,DXd} described non-linear portion which accounted for both the non-linear formation of DXd as well as non-linear elimination.

$$CL_{ns} = CL_{inf} \cdot \left(1 + CL_{inf,EMAX} \cdot \frac{T_{50}^y}{T_{50}^y + time^y} \right)$$

CL_{ns}: non-specific linear clearance at infinity after dosing Q3W.
CL_{inf,EMAX}: max effect of time on CL_{ns}.
T₅₀: time to half-maximal effect
y: Hill coefficient

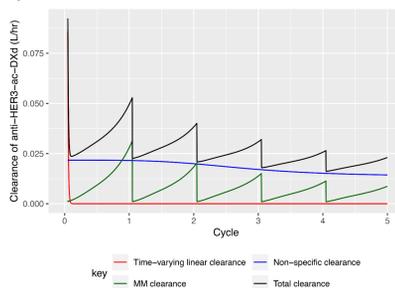
- The CL_{ns} pathway was identified as the major clearance pathway. The initial value at time zero was estimated at 0.0217 L/hr, which gradually decreased over time reaching a steady state value of 0.0143 L/hr. CL_{ns} contributed to 23.5% and 77.6% of total clearance at time zero and steady state, respectively.
- CL_{MM} (CL_{MM} = 0.00934 L/h) contributed to 39.5% of the total clearance at steady state. CL_T contributed a small amount of total clearance. Overall, the total clearance for BC (reference population) at steady-state was 0.0189 L/hr and 0.0180 L/hr for NSCLC.

$$CL_T = CL_T \cdot \exp(-k_{des} \cdot time)$$

$$CL_{MM} = V_{max} / (K_m + ac-DXd)$$

V_{max}: maximal MM elimination
K_m: exposure eliciting half maximum effect

Figure 2. Clearance of anti-HER3-ac-DXd over treatment cycles



Formation and Clearance of DXd

- DXd formation was described by Frac_{ns}, Fract and Frac_{mm} which were the relative fractions of anti-HER3-ac-DXd CL_{ns}, CL_T, and CL_{MM}, respectively.
- Total DXd clearance at steady-state was 17.3 L/hr and 17.9 for BC and NSCLC populations, respectively.

Figure 3. Formation rate of DXd over treatment cycles

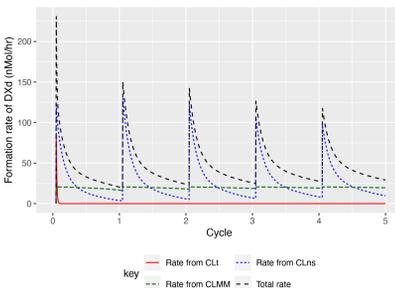
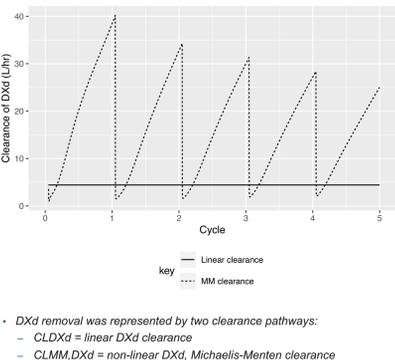


Figure 4. Clearance of DXd over treatment cycles



- DXd removal was represented by two clearance pathways:
 - CL_{DXd} = linear DXd clearance
 - CL_{MM,DXd} = non-linear DXd, Michaelis-Menten clearance

Table 4. Parameter Estimates – Structural Parameters for anti-HER3-ac-DXd

Parameter	Estimate	95% CI
CL _T (L/hr)	exp(θ ₁)	Linear transient clearance 0.0858 0.0185, 0.398
V ₁ (L)	exp(θ ₂)	Central volume of distribution 2.91 2.75, 3.07
Q (L)	exp(θ ₃)	Intercompartmental clearance 0.0221 0.0169, 0.0289
V ₂ (L)	exp(θ ₄)	Peripheral volume of distribution 3.17 2.59, 3.89
K _{des} (1/hr)	exp(θ ₅)	Rate constant of CL _T exponential decline 0.217 0.108, 0.439
CL _{inf} (L/hr)	exp(θ ₆)	Non-specific clearance at infinity 0.0136 0.0106, 0.0173
CL _{inf,max} (-)	exp(θ ₇)	Maximum effect of time on non-specific time-dependent clearance 0.603 0.207, 1.75
T ₅₀ (hr)	exp(θ ₈)	Time to half-maximal time effect 1.38e+03 839, 2.28e+03
y	exp(θ ₉)	Hill coefficient 3.75 0.327, 43.0
V _{max} (nmol/L/hr)	exp(θ ₁₀)	Maximal MM elimination 2.15 1.72, 2.68
K _m (nmol/L)	exp(θ ₁₁)	MM constant 45.8 27.6, 75.9

Table 5. Parameter Estimates – Structural Parameters for DXd

Parameter	Estimate	95% CI
CL _{DXd} (L/hr)	exp(θ ₁₂)	Linear clearance 4.42 3.83, 5.11
V _{1,DXd} (L)	exp(θ ₁₃)	Central volume 5.96 5.40, 6.57
V _{max,DXd} (nmol/L/hr)	exp(θ ₁₄)	Maximal MM elimination 6.18 4.58, 8.35
K _{m,DXd} (nmol/L)	exp(θ ₁₅)	MM constant 0.483 0.342, 0.684
Frac _{ns} (-)	exp(θ ₁₆)	Scaling factor for relative conversion fraction from CL _{ns} 1 FIXED
Frac _T (-)	exp(θ ₁₇)	Scaling factor for relative conversion fraction from CL _T 0.272 0.0670, 1.11
Frac _{mm} (-)	exp(θ ₁₈)	Scaling factor for relative conversion fraction from CL _{MM} 0.272 0.0670, 1.11

Table 6. Parameter Estimates - Covariates

Parameter	Estimate	95% CI
CL _{T,type}	exp(θ ₁₉)	Tumor type effect on CL _T (BC:NSCLC) 0.896 0.455, 1.76
CL _{T,inf}	θ ₂₅	Baseline SLD effect on CL _T -0.0758 -0.269, 0.117
V _{1,sex}	exp(θ ₂₀)	Sex effect on V ₁ (male:female) 1.18 1.04, 1.33
V _{1,race}	exp(θ ₂₁)	Race effect on V ₁ (Asian:non-Asian) 0.927 0.851, 1.01
CL _{inf,sex}	exp(θ ₂₂)	Sex effect on CL _{inf} (male:female) 1.30 1.02, 1.66
CL _{inf,race}	exp(θ ₂₃)	Race effect on CL _{inf} (Asian:non-Asian) 1.02 0.668, 1.55
CL _{inf,ecog}	exp(θ ₂₄)	ECOG effect on CL _{inf} (>0) 1.04 0.612, 1.76
CL _{inf,type}	exp(θ ₂₅)	Tumor type effect on CL _{inf} (BC:NSCLC) 0.937 0.556, 1.58
CL _{inf,hcp}	exp(θ ₂₆)	Hepatic function effect on CL _{inf} (impaired:normal) 0.906 0.752, 1.09
CL _{inf,eGFR}	θ ₃₄	eGFR effect on CL _{inf} -0.302 -1.60, 0.999
CL _{inf,alb}	θ ₃₅	Albumin effect on CL _{inf} -0.490 -0.939, -0.0401
K _{des,SLD}	θ ₃₆	Baseline SLD effect on K _{des} -0.139 -0.391, 0.112
Frac _{ns,sex}	θ ₃₇	Weight effect on Frac _{ns} 0.139 -0.0471, 0.325
Frac _{ns,race}	exp(θ ₃₈)	Sex effect on Frac _{ns} (male:female) 0.848 0.614, 1.17
Frac _{ns,race}	exp(θ ₃₉)	Race effect on Frac _{ns} (Asian:non-Asian) 1.06 0.734, 1.53
Frac _{ns,ecog}	exp(θ ₄₀)	ECOG effect on Frac _{ns} (>0) 1.05 0.818, 1.35
Frac _{ns,type}	exp(θ ₄₁)	Tumor type effect on Frac _{ns} (BC:NSCLC) 1.04 0.752, 1.45
Frac _{ns,hcp}	exp(θ ₄₂)	Hepatic function effect on Frac _{ns} (impaired:normal) 1.09 0.904, 1.30
Frac _{ns,eGFR}	θ ₄₄	eGFR effect on Frac _{ns} 0.0350 -0.999, 1.07
Frac _{ns,alb}	θ ₄₅	Albumin effect on Frac _{ns} -0.271 -0.795, 0.254
CL _{inf}	θ ₄₆	Weight effect on clearance parameters 0.343 0.0521, 0.633
V _{max}	θ ₄₇	Weight effect on volume parameters 0.475 0.124, 0.826

Table 7. Parameter Estimates – Estimates of Variability

Parameter	Estimate	95% CI	Shrinkage
IIV-CL _T	Ω _(1,1)	0.299 [CV%=59.0]	-0.490, 1.09 24.9
IIV-V ₁	Ω _(2,2)	0.0205 [CV%=14.4]	-0.0122, 0.0533 7.19
IIV-Q	Ω _(3,3)	0.431 [CV%=73.4]	-0.236, 1.10 18.7
IIV-V ₂	Ω _(4,4)	0.112 [CV%=34.5]	-0.218, 0.443 20.2
IIV-CL _{inf}	Ω _(6,6)	0.127 [CV%=36.9]	-0.143, 0.398 5.17
IIV-T ₅₀	Ω _(8,8)	0.702 [CV%=101]	-0.166, 1.57 22.4
IIV-CL _{DXd}	Ω _(12,12)	0.108 [CV%=33.7]	-0.208, 0.423 17.8
IIV-V _{1,DXd}	Ω _(13,13)	0.00515 [CV%=7.18]	-0.0626, 0.0729 66.4
IIV-Frac _{ns}	Ω _(16,16)	0.0380 [CV%=19.7]	-0.119, 0.195 12.6
RV on anti-HER3-ac-DXd	Σ _(1,1)	0.0342 [CV%=18.5]	0.0269, 0.0415 6.63
RV on DXd	Σ _(2,2)	0.0814 [CV%=28.5]	0.0612, 0.102 8.78

Diagnostics: Goodness of fit plots

- Figure 5: Population predictions (left panels) vs observed, and individual predictions (right panels) vs observed for anti-HER3-ac-DXd (top panels) and DXd (bottom panels). Observed values are indicated by solid black circles. The line of identity (solid grey) is included as a reference (y=x). The dashed blue line represents a LOESS smooth through the data.

Figure 5.