

Medical Policy



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Title: **Circulating Tumor DNA and Circulating Tumor Cells for Cancer Management (Liquid Biopsy)**

Related Policies:	<ul style="list-style-type: none">▪ <i>Gene Expression Profiling and Protein Biomarkers for Prostate Cancer Management</i>▪ <i>Comprehensive Genetic Profiling for Selecting Targeted Cancer Therapies</i>▪ <i>Gene Expression Profiling for Cutaneous Melanoma</i>▪ <i>Germline and Somatic Biomarker Testing (including Liquid Biopsy) for Targeted Treatment in Breast Cancer (BRCA1, BRCA2, PIK3CA, Ki-67, RET, BRAF, ESR1, NTRK)</i>▪ <i>Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment and Immunotherapy in Metastatic Colorectal Cancer (KRAS, NRAS, BRAF, NTRK, and HER2)</i>▪ <i>Gene Expression Profile Testing and Circulating Tumor DNA Testing for Predicting Recurrence in Colon Cancer</i>
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Professional / Institutional

Original Effective Date: February 27, 2021

Latest Review Date: January 5, 2026

Current Effective Date: October 2, 2023

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Populations	Interventions	Comparators	Outcomes
Individuals: • With advanced cancer	Interventions of interest are: • Testing of circulating tumor cells to select targeted treatment	Comparators of interest are: • Using tissue biopsy to select treatment	Relevant outcomes include: • Overall survival • Disease-specific survival • Test validity • Morbid events • Medication use
Individuals: • With cancer	Interventions of interest are: • Testing of circulating tumor DNA to monitor treatment response	Comparators of interest are: • Standard methods for monitoring treatment response	Relevant outcomes include: • Overall survival • Disease-specific survival • Test validity • Morbid events • Medication use
Individuals: • With cancer	Interventions of interest are: • Testing of circulating tumor cells to monitor treatment response	Comparators of interest are: • Standard methods for monitoring treatment response	Relevant outcomes include: • Overall survival • Disease-specific survival • Test validity • Morbid events • Medication use
Individuals: • Who have received curative treatment for cancer	Interventions of interest are: • Testing of circulating tumor DNA to predict risk of relapse	Comparators of interest are: • Standard methods for predicting relapse	Relevant outcomes include: • Overall survival • Disease-specific survival • Test validity • Morbid events • Medication use
Individuals: • Who have received curative treatment for cancer	Interventions of interest are: • Testing of circulating tumor cells to predict risk of relapse	Comparators of interest are: • Standard methods for predicting relapse	Relevant outcomes include: • Overall survival • Disease-specific survival • Test validity • Morbid events • Medication use

DESCRIPTION

Circulating tumor DNA (ctDNA) and circulating tumor cells (CTCs) in peripheral blood, referred to as "liquid biopsy," have several potential uses for guiding therapeutic decisions in patients with cancer or being screened for cancer. This evidence review evaluates uses for liquid biopsies *not addressed in a separate review*. If a separate evidence review exists, then conclusions reached there supersede conclusions here.

OBJECTIVE

The objective of this evidence review is to determine whether circulating tumor DNA or circulating tumor cell testing in individuals with cancer or at risk of developing cancer improves the net health outcome compared with standard screening as well as diagnostic and management practices. This evidence review evaluates uses for liquid biopsies *not addressed in a separate review*. If a separate evidence review exists, then conclusions reached there supersede conclusions here.

BACKGROUND

Liquid Biopsy

Liquid biopsy refers to the analysis of circulating tumor DNA (ctDNA) or circulating tumor cells (CTCs) as methods of noninvasively characterizing tumors and tumor genome from the peripheral blood.

Circulating Tumor DNA

Normal and tumor cells release small fragments of DNA into the blood, which is referred to as cell-free DNA. Cell-free DNA from nonmalignant cells is released by apoptosis. Most cell-free tumor DNA is derived from apoptotic and/or necrotic tumor cells, either from the primary tumor, metastases, or CTCs.¹ Unlike apoptosis, necrosis is considered a pathologic process and generates larger DNA fragments due to incomplete and random digestion of genomic DNA. The length or integrity of the circulating DNA can potentially distinguish between apoptotic and necrotic origin. Circulating tumor DNA can be used for genomic characterization of the tumor.

Circulating Tumor Cells

Intact CTCs are released from a primary tumor and/or a metastatic site into the bloodstream. The half-life of a CTC in the bloodstream is short (1 to 2 hours), and CTCs are cleared through extravasation into secondary organs.¹ Most assays detect CTCs through the use of surface epithelial markers such as epithelial cell adhesion molecules (EpCAM) and cytokeratins. The primary reason for detecting CTCs is prognostic, through quantification of circulating levels.

Detecting Circulating Tumor DNA and Circulating Tumor Cells

Detection of ctDNA is challenging because ctDNA is diluted by nonmalignant circulating DNA and usually represents a small fraction (<1%) of total cell-free DNA. Therefore, more sensitive methods than the standard sequencing approaches (eg, Sanger sequencing) are needed.

Highly sensitive and specific methods have been developed to detect ctDNA, for both single nucleotide variants (eg BEAMing [which combines emulsion polymerase chain reaction with magnetic beads and flow cytometry] and digital polymerase chain reaction) and copy-number variants. Digital genomic technologies allow for enumeration of rare variants in complex mixtures of DNA.

Approaches to detecting ctDNA can be considered targeted, which includes the analysis of known genetic mutations from the primary tumor in a small set of frequently occurring driver mutations, which can impact therapy decisions, or untargeted without knowledge of specific variants present

in the primary tumor, and include array comparative genomic hybridization, next-generation sequencing, and whole exome and genome sequencing.

Circulating tumor cell assays usually start with an enrichment step that increases the concentration of CTCs, either by biologic properties (expression of protein markers) or physical properties (size, density, electric charge). Circulating tumor cells can then be detected using immunologic, molecular, or functional assays.¹

Note that targeted therapy in non-small-cell lung cancer and metastatic colorectal cancer, use of liquid biopsy for detection or risk assessment of prostate cancer, and use of AR-V7 CTC liquid biopsy for metastatic prostate cancer are addressed in separate reviews.

REGULATORY STATUS

Clinical laboratories may develop and validate tests in-house and market them as a laboratory service; laboratory-developed tests must meet the general regulatory standards of the Clinical Laboratory Improvement Amendments. Laboratories that offer laboratory-developed tests must be licensed by the Clinical Laboratory Improvement Amendments for high-complexity testing. To date, the U.S. Food and Drug Administration (FDA) has chosen not to require any regulatory review of this test.

Certain liquid biopsy-based assays have been cleared or approved by the FDA as companion diagnostic tests (Table 1).² These indication are addressed in other evidence opinions and are listed here for information only. Refer to the associated evidence opinion (Column 5) for details.

Table 1. FDA Cleared or Approved Liquid Biopsy Companion Diagnostic Tests

Diagnostic Name (Manufacturer)	Indication	Biomarker	Drug Trade Name (Generic)	Related Medical Policy
Agilent Resolution ctDx FIRST assay	NSCLC	KRAS	Krazati (adagrasib)	Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment in Non-Small-Cell Lung Cancer (<i>EGFR, ALK, BRAF, ROS1, RET, MET, KRAS, NTRK</i>)
cobas EGFR Mutation Test v2 (Roche Molecular Systems, Inc.)	NSCLC	<i>EGFR (HER1)</i>	Tagrisso (osimertinib)	
	NSCLC	<i>EGFR (HER1)</i>	Iressa (gefitinib)	
	NSCLC	<i>EGFR (HER1)</i>	Tarceva (erlotinib)	
	NSCLC	<i>EGFR (HER1)</i>	Gilotrif (afatinib)	
FoundationOne Liquid CDx (Foundation Medicine, Inc.)	NSCLC	<i>EGFR (HER1)</i>	Exkivity (mobocertinib)	
	NSCLC	<i>EGFR (HER1)</i>	Iressa (gefitinib)	
	NSCLC	<i>EGFR (HER1)</i>	Tagrisso (osimertinib)	
	NSCLC	<i>EGFR (HER1)</i>	Tarceva (erlotinib)	
	NSCLC	<i>MET</i>	Tabrecta (capmatinib)	
	NSCLC	<i>ROS1</i>	Rozlytrek (entrectinib)	Germline and Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment in Breast Cancer (<i>BRCA1, BRCA2, PIK3CA, Ki-67, RET, BRAF, ESR1, NTRK</i>)
	NSCLC	ALK	Alecensa (alectinib)	
	Breast Cancer	<i>PIK3CA</i>	Piqray (alpelisib)	Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment in Non-Small-Cell Lung Cancer (<i>EGFR, ALK, BRAF, ROS1, RET, MET, KRAS, NTRK</i>)
Guardant360 CDx (Guardant Health, Inc.)	NSCLC	<i>EGFR (HER1)</i>	Tagrisso (osimertinib)	
	NSCLC	<i>EGFR (HER1)</i>	Rybrevant (amivantamb)	

Diagnostic Name (Manufacturer)	Indication	Biomarker	Drug Trade Name (Generic)	Related Medical Policy
	NSCLC	<i>KRAS</i>	Lumakras (sotorasib)	Cell Lung Cancer (<i>EGFR</i> , <i>ALK</i> , <i>BRAF</i> , <i>ROS1</i> , <i>RET</i> , <i>MET</i> , <i>KRAS</i> , <i>NTRK</i>)
	NSCLC	<i>ERBB2</i>	ENHERTU (fam-trastuzumab deruxtecan-nxki)	
<i>therascreen PIK3CA RGQ PCR Kit (QIAGEN GmbH)</i>	Breast Cancer	<i>ESR1</i> <i>ERB2</i>	Orserdu (elacestrant) ENHERTU (fam-trastuzumab deruxtecan-nxki)	Germline and Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment in Breast Cancer (<i>BRCA1</i> , <i>BRCA2</i> , <i>PIK3CA</i> , Ki-67, <i>RET</i> , <i>BRAF</i> , <i>ESR1</i> , <i>NTRK</i>)
	Breast Cancer	<i>PIK3CA</i>	Piqray (alpelisib)	
xT CDx (Tempus Labs, Inc.)	Colorectal Cancer	<i>KRAS</i>	Erbitux (cetuximab)	Somatic Biomarker Testing (Including Liquid Biopsy) for Targeted Treatment in Metastatic Colorectal Cancer (<i>KRAS</i> , <i>NRAS</i> , <i>BRAF</i> , <i>NTRK</i> , <i>RET</i> and <i>HER2</i>)
	Colorectal Cancer	<i>KRAS</i> and <i>NRAS</i>	Vectibix (panitumumab)	

Source: FDA (2025)²

FDA: US Food and Drug Administration; NSCLC: non-small cell lung cancer

POLICY

The use of circulating tumor DNA and/or circulating tumor cells is considered **experimental / investigational** for all indications reviewed herein not otherwise addressed in policy guidelines.

POLICY GUIDELINES

This policy does not address the use of blood-based testing (liquid biopsy) to select targeted treatment for breast cancer, non-small cell lung cancer, melanoma/glioma, ovarian cancer, pancreatic cancer, and prostate cancer, the use of liquid biopsy to select immune checkpoint inhibitor therapy, tumor-Informed circulating tumor DNA testing for cancer management, comprehensive genomic profiling for selecting targeted cancer therapies, the use of blood-based testing for detection or risk assessment of prostate cancer; or the use of AR-V7 circulating tumor cells for metastatic prostate cancer.

Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

RATIONALE

This evidence review was created using searches of the PubMed database. The most recent literature update was performed through October, 24 2025.

Evidence reviews assess whether a medical test is clinically useful. A useful test provides information to make a clinical management decision that improves the net health outcome. That is, the balance of benefits and harms is better when the test is used to manage the condition than when another test or no test is used to manage the condition.

The first step in assessing a medical test is to formulate the clinical context and purpose of the test. The test must be technically reliable, clinically valid, and clinically useful for that purpose. Evidence reviews assess the evidence on whether a test is clinically valid and clinically useful. Technical reliability is outside the scope of these reviews, and credible information on technical reliability is available from other sources.

This evidence review evaluates uses for liquid biopsies not addressed in other reviews. If a separate evidence review exists, then conclusions reached their supersede conclusions here. The main criterion for inclusion in this review is the limited evidence on clinical validity.

SELECTING TREATMENT IN ADVANCED CANCER

Clinical Context and Test Purpose

One purpose of liquid biopsy testing of individuals who have advanced cancer is to inform a decision regarding treatment selection (eg, whether to select a targeted treatment or standard treatment). Treatment selection is informed by tumor type, grade, stage, individual performance status and preference, prior treatments, and the molecular characteristics of the tumor such as the presence of driver mutations.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest are individuals with advanced cancer for whom the selection of treatment depends on the molecular characterization of the tumor(s).

Interventions

The test being considered is liquid biopsy using circulating tumor cells (CTCs). Both targeted polymerase chain reaction-based assays and broad next-generation sequencing-based approaches are available. Individuals with negative liquid biopsy results should be reflexed to tumor biopsy testing if they are able to undergo tissue biopsy.³

Comparators

For individuals who are able to undergo a biopsy, molecular characterization of the tumor is performed using standard tissue biopsy samples. Patients unable to undergo a biopsy generally receive standard therapy.

Outcomes

Liquid biopsies are easier to obtain and less invasive than tissue biopsies. True-positive liquid biopsy test results lead to the initiation of appropriate treatment (eg, targeted therapy) without a tissue biopsy. False-positive liquid biopsy test results lead to the initiation of inappropriate therapy, which could shorten progression-free survival.

In individuals able to undergo a tissue biopsy, negative liquid biopsies reflex to tissue testing. In individuals unable to undergo a tissue biopsy, a negative liquid biopsy result would not change empirical treatment. Therefore, health outcomes related to negative test results do not differ between liquid biopsy and tissue biopsy.

The timing of interest for survival outcomes varies by type of cancer.

REVIEW OF EVIDENCE

Clinically Valid

A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

Circulating Tumor Cells

The clinical validity of each commercially available CTC test must be established independently, which has not been done to date.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs.

Trials of using CTCs to select treatment are ongoing (see Table 7 in Supplemental Information).

Chain of Evidence

Indirect evidence on clinical utility rests on clinical validity. If the evidence is insufficient to demonstrate test performance, no inferences can be made about clinical utility.

The evidence is insufficient to demonstrate test performance for currently available CTC tests; therefore, no inferences can be made about clinical utility.

Section Summary: Selecting Treatment in Advanced Cancer

For indications reviewed herein, there is no direct evidence that selecting targeted treatment using CTCs improves the net health outcome compared with selecting targeted treatment using tumor tissue testing. Trials are ongoing. Given the breadth of methodologies available to assess CTCs, the clinical validity of each commercially available test must be established independently, and these data are lacking. The evidence is insufficient to demonstrate test performance for currently available CTC tests that are reviewed herein; therefore, no inferences can be made about clinical utility through a chain of evidence.

MONITORING TREATMENT RESPONSE IN CANCER

Clinical Context and Test Purpose

Monitoring of treatment response in cancer may be performed using tissue biopsy or imaging methods. Another proposed purpose of liquid biopsy testing in individuals who have advanced cancer is to monitor treatment response, which could allow for changing therapy before clinical progression and potentially improve outcomes.

The following PICO was used to select literature to inform this review.

Patients

The relevant population of interest are individuals who are being treated for cancer.

Interventions

The test being considered is liquid biopsy using either ctDNA or CTCs. For ctDNA tests, the best unit for quantifying DNA burden has not been established.³ The kinetics of ctDNA correlate with treatment response and may identify responses earlier than clinical/radiological detection. Across multiple different tumor types, and type of treatment (chemotherapy, targeted therapy, and immunotherapy), patients who respond to treatment have a drop in ctDNA levels within weeks of starting therapy.⁴

Comparators

Standard monitoring methods for assessing treatment response are tissue biopsy or imaging methods.

Outcomes

The outcomes of primary interest are progression-free survival (PFS) and overall survival (OS).

The timing of interest for survival outcomes varies by type of cancer.

PREDICTING RISK OF RELAPSE

Clinical Context and Test Purpose

Monitoring for relapse after curative therapy in individuals with cancer may be performed using imaging methods and clinical examination. Another proposed purpose of liquid biopsy testing in individuals who have cancer is to monitor for residual tumor, which could lead to early treatment that would eradicate residual disease and potentially improve outcomes.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest are individuals who have received curative treatment for cancer.

Interventions

The test being considered is liquid biopsy using either ctDNA or CTCs. Substantial evidence suggests that detection of ctDNA following potentially curative treatment is associated with a high-risk of future relapse with two terms, minimal/molecular residual disease (MRD) and molecular relapse (MR), commonly used in the literature for predicting relapse via liquid biopsy. To ensure benefit of early treatment and limit false-negative cases, it is critical that assays can detect ultra-low ctDNA concentrations.⁴

Comparators

Standard monitoring methods for detecting relapse are imaging methods and clinical examination.

Outcomes

The outcomes of primary interest are OS, disease-specific survival, test validity, morbid events, and medication use.

The timing of interest for survival outcomes varies by type of cancer.

REVIEW OF EVIDENCE

Clinically Valid

A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

Circulating Tumor DNA

Merker et al (2018) identified several proof-of-principle studies demonstrating correlations between changes in ctDNA levels and tumor response or outcomes, as well as studies demonstrating that ctDNA can identify the emergence of resistant variants.³

Randomized Clinical Trials

Numerous randomized clinical trials (RCTs) have investigated ctDNA testing as an exploratory analysis either prospectively or retrospectively as a post hoc analysis to determine the utility of ctDNA testing in the management of cancer. Characteristics of these RCTs are listed in Table 2 with their key results recorded in Table 3.

Table 2. Summary of Key Characteristics of Randomized Clinical Trials on Circulating Tumor DNA Testing in Individuals with Cancer

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
Ruiz-Vico et al (2025) ⁵	Global	89	Patients with histologically confirmed prostate adenocarcinoma, bone or soft tissue metastases, progression despite serum testosterone ≤1.73 nmol/l, and ECOG performance status 0–1	An exploratory analysis of the PRESIDE (NCT02288247), a multicenter, two-period, double-blind, randomized, placebo-controlled phase 3b clinical trial, to assess the associations of PFS and circulating tumor DNA (ctDNA) prior to and after one cycle of docetaxel.	Enzalutamide	Placebo
LaPelusa et al (2025) ⁶	U.S.	1	Patients ≥18 years of age with locally advanced, histologically confirmed deficient mismatch repair/microsatellite instability-high solid tumors.	An exploratory analysis of a phase II clinical trial (NCT04082572) to investigate the ctDNA kinetics over the course of treatment with pembrolizumab to determine whether ctDNA has utility as a biomarker for pathologic complete response, event-free survival, and overall survival.	Pembrolizumab	None

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
Rodrigues et al (2024) ⁷	France	5	Patients ≥18 years of age with any tumoral disease (proven or suspected), of any type and stage.	An exploratory analysis of the phase II, IMCgp100-102, and phase III, IMCgp100-202 tebentafusp, clinical trials (NCT02866149) on blood-borne biological markers and their correlation with clinical and pathological characteristics.	Tebentafusp	None
Knutson et al (2024) ⁸	U.S., Canada, and Puerto Rico	539	Men ≥18 years of age with previously untreated metastatic castration-resistant prostate cancer and progressive metastatic disease despite ongoing androgen deprivation therapy.	An exploratory liquid biopsy analysis of plasma cell free DNA from patients who enrolled in the randomized phase III clinical trial, Alliance A031201 (NCT01949337), to interrogate the utility of ctDNA in understanding clinical outcomes.	Enzalutamide	Enzalutamide plus abiraterone and prednisone
Han et al (2024) ⁹	South Korea	16	Patients ≥20 years of age with histologically or cytologically confirmed diagnosis of advanced <i>EGFR</i> -mutated non-small cell lung cancer, ECOG performance status 0 to 1, at least one measurable extracranial lesion, and confirmed T790M+ variant status, and previous therapy	An exploratory analysis of a multicenter, open-label, phase 1/2 clinical trial, LASER201 study (NCT03046992), to assess the relationship of ctDNA testing for <i>EGFR</i> variants and efficacy parameters.	Lazertinib	None

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
			with <i>EGFR</i> tyrosine kinase inhibitors.			
Herbst et al (2025) ¹⁰	U.S., Japan and China	210	Patients ≥18 years of age (20 years or older in Japan and Taiwan) and had postsurgical stage IB (T2a tumors >3 cm and ≤5 cm in size), II or IIIA non-small cell lung cancer, with a centrally confirmed <i>EGFR</i> mutation (Ex19del/L858R) and a World Health Organization performance status of 0 or 1.	An exploratory analysis of the ADAURA phase III trial (NCT02511106) to investigate whether plasma-based, tumor-informed MRD analysis (ctDNA) could predict disease recurrence during and after adjuvant treatment in 220 patients with viable ctDNA during or after adjuvant therapy with Osimertinib.	Osimertinib	Placebo
Syeda et al (2025) ¹¹	Global	210	Patients with completely resected, histologically confirmed, <i>BRAFV600E/K</i> mutation-positive, high-risk [Stage IIIa (lymph node metastasis >1 mm), IIIb, or IIIc] cutaneous melanoma were screened for eligibility and had undergone complete lymphadenectomy with no clinical or radiographic evidence of residual regional node disease within 12 weeks before randomization, had recovered from definitive surgery, and had an ECOG performance status of 0 or 1.	A biomarker analysis from a double-blind, randomized phase 3 trial (COMBI-AD; NCT01682083) to investigate whether ctDNA could predict survival outcomes during adjuvant targeted therapy or placebo treatment in stage II melanoma.	Dabrafenib or Trametinib	Placebo
Ademuyiwa et al (2025) ¹²	U.S.	1	Patients ≥18 years of age, with newly diagnosed AJCC7 clinical stage II or III breast cancer with complete	A biomarker analysis of a single arm open label phase II study on patients	docetaxel and carboplatin	Historical controls

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
			surgical excision of the breast cancer after neoadjuvant chemotherapy as the treatment goal, an ECOG performance status <2.	with stage II or III TNBC undergoing neoadjuvant docetaxel and carboplatin chemotherapy on a clinical trial (NCT02124902) followed by surgery with or without adjuvant therapy were included in this study to determine the postoperative surveillance sensitivity and specificity for detecting distant metastatic recurrence in patients with TNBC.		
Yoo et al (2025) ¹³	South Korea	1	Patients ≥19 years of age, with histologically confirmed extrahepatic cholangiocarcinoma , complete (R0 or R1) surgical resection within 12 weeks before randomization, and metastasis to at least one regional lymph node.	A biomarker analysis from a multicenter, open-label, randomized phase II study (STAMP) of 89 patients. Longitudinal plasma samples (n = 254) were prospectively collected post-surgery before ACT, and on-ACT at 12 and 24 weeks from cycle 1 day 1 (C1D1). ctDNA was evaluated using a personalized, tumor-informed, 16-plex PCR next-generation	Gemcitabine plus cisplatin	Capecitabine

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
				sequencing assay and was correlated with clinical outcomes.		
Taieb et al (2025) ¹⁴	France and Greece	153	Patients ≥18 years and older, with stage III histologically confirmed colon cancer, curative-intent surgery no more than 8 weeks before random assignment, an ECOG performance status of 0 or 1, and postoperative carcinoembryonic antigen (CEA) level <10 ng/mL.	A biomarker analysis from two multicenter, two-arm, open-label, randomized phase III trials (IDEA-France, NCT00958737, and IDEA-Greece, NCT01308066, trials). Plasma samples (ctDNA) were collected after surgery or before ACT and analyzed for time to recurrence (TTR; patients without recurrence or death due to colon cancer) and overall survival (OS). Treatment was randomly assigned (1:1) to 3 or 6 months of adjuvant chemotherapy.	modified FOLFOX6	capecitabine plus oxaliplatin
Mayadever al (2025) ¹⁵	Global	117	Adult women with untreated histologically and radiologically confirmed cervical adenocarcinoma, squamous carcinoma, or adenosquamous carcinoma, International Federation of Gynaecology and Obstetrics (FIGO) 2009 stage IB2-IIIB node	An exploratory analysis in a large cohort of patients from a phase III, randomized, double-blind, placebo-controlled trial (CALLA study; NCT03830866) to evaluate the	Durvalumab with CRT	Placebo

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
			positive, or stage IIIA-IVA node positive or negative, no evidence of metastatic disease with a World Health Organization or ECOG performance status of 0 or 1, at least one lesion measurable by RECIST version 1.1, and adequate organ and marrow function were enrolled.	association of pretreatment and on-treatment ctDNA levels with long-term clinical outcomes and patient baseline disease characteristics in the context of locally advanced cervical cancer.		
Long et al (2025) ¹⁶	Global	124	Patients ≥ 12 with resected stage IIIB-D or IV melanoma and no evidence of residual disease on radiographical assessment and had an ECOG performance status of 0 or 1 were randomized 1:1 to receive nivolumab monotherapy 480mg once every 4 weeks or nivolumab 240mg every 2 weeks + ipilimumab 1mg/kg every 6 weeks.	An exploratory analysis from the CheckMate 915 trial (NCT03068455) to evaluate tumor and peripheral biomarkers, including tumor-informed ctDNA at postresection baseline and on-treatment, for their association with RFS and distant metastases-free survival.	Nivolumab + Ipilimumab	Nivolumab
Azaïs et al (2025) ¹⁷	France	36	Female patients ≥ 18 with histological confirmed (cytology alone excluded) epithelial ovarian cancer, fallopian tube, or primary peritoneal cancer, FIGO-Stages IIIC - IV, an ECOG performance status <2 , refusal of primary debulking surgery and maximum surgical effort of cytoreduction with the goal of no residual disease planned as interval debulking surgery.	An exploratory analysis of the prospective CHIVA (NCT01583322) phase II trial to evaluate the prognostic impact of ctDNA detection and quantification at diagnosis and of its early decrease after one cycle of neoadjuvant chemotherapy	Vargatef + Nintedanib	Placebo

Study	Countries	Sites	Participants	Methods	Interventions	
					Active	Comparator
				(NACT) in a cohort of patients with advanced epithelial ovarian cancer.		

ACT: adjuvant chemotherapy; AJCC: American Joint Committee on Cancer; CRT: chemoradiotherapy; ctDNA: circulating tumor DNA; C1D1: cycle 1 day 1; DFS: disease-free survival; ECOG: Eastern Cooperative Oncology Group; EFS: event-free survival; EGFR: epidermal growth factor receptor; HR: hazard ratio; MRD: molecular/minimal residual disease; NA: not applicable; NR: not reported; PFS: progression-free survival; OS: overall survival; RFS: Recurrence-free survival

Table 3. Results from RCTs on Circulating Tumor DNA Testing in Individuals with Cancer

Study	PFS (HR, 95% CI)	OS (95% CI)	EFS (%, 95% CI)	DFS (HR, 95% CI)	RFS (HR, 95% CI)	p value
Ruiz-Vico et al (2025) ^{a5} ,	ctDNA at baseline: 1.78 (1.20 to 2.64) ctDNA at C2D1: 1.95 (1.15 to 3.30)	NR	NR	NR	NR	p=.004 p=.019
LaPelusa et al (2025) ^{b6} ,	NR	ctDNA(-): 100% (1.00 to 1.00) ctDNA(+): 80% (0.52 to 1.00)	ctDNA(-): 92% (0.83 to 1.00) ctDNA(+): 20% (0.03 to 1.00)	NR	NR	OS: p<.001 EFS: p<.001
Rodrigues et al (2024) ⁷ ,	Univariate analysis: 2.8 (1.5 to 5.2) Multivariate analysis: 2.5 (1.1 to 5.9) ^d 5.8 (2.1 to 16.5) ^e	Univariate analysis: HR=10.1 (3.0 to 33.8) Multivariate analysis HR = 9.3 (1.9 to 45.2) ^d HR = 49.6 (4.5 to 544.5) ^e	NR	NR	NR	Univariate analysis: PFS: p=.001 OS: p<.001 Multivariate analysis: PFS: p=.004 OS: p=.006
Knutson et al (2024) ^{c8} ,	1.8 (1.5 to 2.1)	HR: 2.0 (1.7 to 2.4)	NR	NR	NR	PFS: p=8.8x10 ⁻¹² OS: p=3.2x10 ⁻¹⁴

Study	PFS (HR, 95% CI)	OS (95% CI)	EFS (%, 95% CI)	DFS (HR, 95% CI)	RFS (HR, 95% CI)	p value
Han et al (2024) ^{a9} ,	ctDNA at baseline: 0.30 (0.15 to 0.59) ctDNA at cycle 3: 0.28 (0.12 to 0.64)	Baseline ctDNA: HR=0.35 (0.14 to 0.90) Cycle 3 ctDNA: HR=0.86 (0.19 to 3.95)	NR	NR	NR	Baseline ctDNA: PFS: p=.0004 OS: NR Cycle 3 ctDNA: PFS: p=.0026 OS: NR
Herbst et al (2025) ¹⁰ ,	NR	HR=0.19 (0.12 to 0.29) ^f	NR	0.42 (0.24 to 0.74) ^f	NR	NR
Syeda et al (2025) ^{a11} ,	NR	ctDNA(+): Placebo: HR=3.35 (2.01 to 5.55) Combination therapy: HR=4.27 (2.50 to 7.27)	NR	NR	ctDNA(+): Placebo: HR=2.91 (1.99 to 4.25) Combination therapy: HR=2.98 (1.95 to 4.54)	OS: p<.0001 RFS: p<.0001
Ademuyiwa et al (2025) ¹² ,	NR	NR	NR	NR	post-surgery: 38.8 (32 to 4,761) ^j post-surgery: 37.7 (1.49 to 951) ^j	p<.0001 (both)
Yoo et al (2025) ¹³ ,	NR	ctDNA(-) converted ctDNA(+): HR=3.0 (1.48 to 6.1) ^g Persistently ctDNA(+): HR=4.0 (1.88 to 8.3) ^g	NR	MRD window:1.8 (1.06 to 3.07) ^a post-surgery:3.81 (2.22 to 6.54) ^a 12wks after C1D1: 7.72 (4.09 to 14.56) ^a 24wks after C1D1: 5.24 (2.75 to 9.97) ^a	NR	OS: p =.002 & p<.001 DFS: p=.029 p<.001 p<.001 p<.001

Study	PFS (HR, 95% CI)	OS (95% CI)	EFS (% , 95% CI)	DFS (HR, 95% CI)	RFS (HR, 95% CI)	p value
Taieb et al (2025) ¹⁴	NR	5.21 (3.59 to 7.58) ^a	NR	NR	4.84 (3.40 to 6.89) ^a	OS: p<.001 RFS: p<.001
Mayadev er al (2025) ¹⁵	ctDNA at baseline: 1.72 (0.99 to 3.00) ^h ctDNA at C1D1: 5.27 (2.95 to 9.40) ^a	NR	NR	NR	NR	PFS: p=.054 and p<.001
Long et al (2025) ¹⁶	NR	NR	NR	NR	1.97 (1.57 to 2.46) ^a	NR
Azaïs et al (2025) ¹⁷	1.68 (1.03 to 2.74) ⁱ	1.83 (1.02 to 3.26) ⁱ	NR	NR	NR	PFS: p=.02 OS: p=.043

ACT: adjuvant chemotherapy; ctDNA: circulating tumor DNA; C1D1: cycle 1 day 1; DFS: disease-free survival; EFS: event-free survival; HR: hazard ratio; MRD: molecular/minimal residual disease; NR: not reported; OS: overall survival; RFS: Recurrence-free survival

^a ctDNA detection versus negative.

^b ctDNA detection after completion of pembrolizumab.

^c ctDNA detection at baseline versus negative; radiographic progression-free survival (rPFS) was used instead of PFS as the statistical endpoint.

^d ctDNA detection at baseline versus negative.

^e ctDNA clearance at 12w (versus negative at baseline and 12w)

^f MRD detected via ctDNA for Osimertinib vs placebo. DFS was analyzed using a log-rank test. Due to the low number of events OS for the MRD analysis set was analyzed by an unstratified log-rank test.

^g The dynamics of ctDNA from the MRD window (pre-ACT) to the time-points on-ACT (12 weeks or 24 weeks from C1D1) were assessed for their association with DFS and OS.

^h ctDNA low levels versus high levels; the median ctDNA level across all samples was 5268.2 parts per million (ppm); this median value was used as a cut-off to define high (greater than or equal to median) and low (less than median) ctDNA levels.

ⁱ ctDNA decrease after 1 cycle of neoadjuvant chemotherapy.

^j Recurrence-free interval (RFI) based on ctDNA detection at the first post-surgery time point analyzed, and RFI based on ctDNA detection at any point after surgery.

Systematic Review and Meta-analysis

Systematic reviews and meta-analyses describing an association between ctDNA and poor prognosis have been reported for esophageal cancer¹⁸, breast cancer,^{19,20}, lung cancer,^{21,22,23,24}, colorectal cancer,^{25,26,27,28,29}, melanoma,^{30,31}, cervical cancer,³², head and neck cancer,³³, bladder cancer,^{34,35,36}, gastrointestinal stromal tumors,³⁷, and solid tumors.³⁸

Observational Studies

Chiang et al (2025) analyzed plasma samples collected from non-small cell lung cancer (NSCLC) and small cell lung cancer (SCLC) patients in the real-world prospective clinico-genomic study (PCG; NCT04180176) to evaluate the validity of circulating tumor DNA (ctDNA) monitoring and to elucidate ctDNA dynamics across 4 different therapy modalities.³⁹ Two primary, pre-specified analyses were performed: first, real-world overall survival (rwOS), real-world progression-free survival (rwPFS), and real-world overall response rate (rwORR) were assessed, segmented by on-

treatment ctDNA detection irrespective of ctDNA levels at enrollment (cohort A). Second, rwOS, rwPFS, and rwORR were compared by levels of ctDNA change from enrollment to on treatment (cohort B) with a prespecified cutoffs of 90 and 50 percent decrease were used to define a molecular response. Cohorts A and B included patients with liquid biopsies collected 6- to 15-weeks after the start of therapy, regardless of the timing of their first tumor assessment or whether the specimen was collected at disease progression. Each cohort was subjected to a subgroup analysis consisting of an exploratory group (patients tested with the prototype assay and any patients with NSCLC treated with non-immune-checkpoint inhibitor [ICIs] regimens, NSCLC validity group [patients with NSCLC treated with ICI-containing regimens and tested with the analytically validated assay], and SCLC validity group [patients receiving all regimens and tested with FoundationOne CDx]). Real-world data of ctDNA monitoring for prognosticating favorable outcomes to standard-of-care therapies for patients with lung cancer are presented in Table 4. To understand if a molecular response determined by ctDNA analysis measures up to traditional imaging methods, patients were grouped by radiographic and ctDNA responses. In all patients with NSCLC (exploratory and validity), those with both complete or partial response (confirmed via real-world radiographic imaging) and molecular response via ctDNA had substantially better outcomes (rwPFS: 10.4 months and rwOS: 28.2 months), whereas patients with neither radiographic nor molecular response had worse outcomes (rwPFS: 2.7 mo and rwOS: 8.2 months). Molecular response via ctDNA was associated with superior rwPFS and rwOS among patients with a documented real-world response (rwPFS HR: 0.31, 95% CI: 0.17 to 0.55; rwOS HR: 0.20, 95% CI: 0.10 to 0.41) than those with no real-world response (rwPFS HR: 0.22, 95% CI: 0.11 to 0.45; rwOS HR: 0.47, 95% CI: 0.24 to 90). Furthermore, a molecular response determined by ctDNA remained independently associated with rwOS in all NSCLC patients (HR: 0.50, 95% CI: 0.28 to 0.89). The results of this study suggest that ctDNA may be able to aid clinicians in deciding whether or not to cease, intensify, or de-intensify treatment for individuals with lung cancer. However, notable limitations include, but are not limited to, real-world assessments are not analogous to response evaluation criteria in solid tumors (RECIST), limited to patients with specimen collection 6- to 15-weeks, and variability within the timing and assessment (on-treatment or after progression) of ctDNA, sample collection (plasma or blood), and treatment regimen.

Table 4. Results of Circulating DNA (ctDNA) Response Monitoring in Lung Cancers: Clinico-Genomic Study (NCT04180176)

	Exploratory Analysis		NSCLC Validity Analysis		SCLC Validity Analysis	
Cohort A (n=450 patients) ^a	ctDNA detected	ctDNA not detected	ctDNA detected	ctDNA not detected	ctDNA detected	ctDNA not detected
Median PFS (95% CI)	3.9 (3.0 to 5.4)	8.5 (7.7 to 10.7)	3.3 (2.8 to 4.1)	9.8 (8.3 to 13.2)	4.3 (3.8 to 5.7)	6.1 (5.1 to 9.7)
Hazard Ratio (95% CI)	0.42 (0.30 to 0.58)		0.26 (0.18 to 0.40)		0.39 (0.19 to 0.80)	
Log-rank p	<.0001		<.0001		<.01	

	Exploratory Analysis		NSCLC Validity Analysis		SCLC Validity Analysis	
Median OS (95% CI)	8.8 (8.0 to 11.4)	21.8 (19.5 to 26.1)	9.5 (7.7 to 14.6)	23.5 (18.7 to 29.2)	8.3 (6.0 to 11.3)	15.9 (9.6 to 20.6)
Hazard Ratio (95% CI)	0.35 (0.24 to 0.50)		0.34 (0.22 to 0.53)		0.19 (0.08 to 0.42)	
Log-rank p	<.0001		<.0001		<.0001	
Cohort B (n=245 patients)^b	<90% decrease/increase	≥90% decrease	<90% decrease/increase	≥90% decrease	<90% decrease/increase	≥90% decrease
Median PFS (95% CI)	3.1 (2.8 to 4.0)	7.7 (6.3 to 9.3)	2.8 (2.0 to 4.5)	8.6 (6.8 to 27.3)	4.5 (2.8 to 5.7)	5.6 (4.3 to 9.3)
Hazard Ratio (95% CI)	0.24 (0.16 to 0.36)		0.15 (0.06 to 0.37)		0.33 (0.14 to 0.80)	
Log-rank p	<.0001		<.0001		<.0146	
Median OS (95% CI)	8.3 (7.2–9.7)	17.6 (14.2 to 22.0))	8.4 (6.4 to 16.1)	19.4 (12.6 to NR)	7.2 (4.8 to 11.3)	15.7 (10.3 to 20.6)
Hazard Ratio (95% CI)	0.29 (0.19 to 0.44)		0.18 (0.07 to 0.50)		0.11 (0.04 to 0.33)	
Log-rank p	<.0001		<.001		<.0001	

CI: confidence interval; ctDNA: circulating tumor DNA; OS: overall survival; PFS: progression-free survival

^a Patient outcomes assessed by ctDNA detection status 6 to 15 weeks after the start of therapy

^b Patient outcomes assessed by molecular response (≥90% decrease in ctDNA from enrollment)

The substantial heterogeneity among assays and different timepoints employed in ctDNA analysis across these studies prevents any conclusions that can establish a standardized definition for ctDNA molecular response confounding the clinical validity of ctDNA assays. Furthermore, ctDNA analysis was assessed either as a binary variable (ctDNA positive or negative) or as continuous variable within these studies underscoring the need to consider their varying implications for patient outcomes. Variance in defining ctDNA reduction, often characterized as a decrease in mean variant allele fraction (VAF) or mutant allele frequency (MAF) of tumor-derived alterations over time, and clearance, referring to complete elimination of circulating tumor load, further complicates the interpretation of the results of ctDNA kinetic analysis. Across both ctDNA assays and cancer types, clinical specificity of ctDNA detection for predicting relapse in the absence of further treatment is high, often ≥90% if no further treatment is given after the positive test

result, however, clinical sensitivity of MRD detection, with current assays, shortly after completion of therapy is suboptimal and often $\leq 50\%$.

Circulating Tumor Cells

Systematic reviews and meta-analyses describing an association between CTCs and poor prognosis have been reported for metastatic breast cancer,^{40,41,42,43}, CRC,^{44,45}, hepatocellular cancer,⁴⁶, prostate cancer,^{47,48,49}, head and neck cancer,⁵⁰, Multiple myeloma,⁵¹, and melanoma.⁵²

Circulating Tumor Cells

Rack et al (2014) published the results of a large multicenter study in which CTCs were analyzed in 2026 patients with early breast cancer before adjuvant chemotherapy and in 1492 patients after chemotherapy using the CellSearch® System.⁵³ After chemotherapy, 22% of patients were CTC-positive, and CTC positivity was negatively associated with prognosis.

Smaller studies demonstrating associations between persistent CTCs and relapse have been published in prostate cancer,⁵⁴, CRC⁵⁵, bladder cancer,^{56,57}, liver cancer,⁵⁸, and esophageal cancer.⁵⁹

The clinical validity of each commercially available CTC test must be established independently, which has not been done to date.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

CIRCULATING TUMOR DNA

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs.

Tie et al (2022) published early data results from a phase 2, multicenter, randomized, controlled clinical trial (DYNAMIC study) in which individuals with stage 2 colon cancer received ctDNA-guided adjuvant chemotherapy (ACT; n=302) or standard of care (SOC; n=153) to assess whether a ctDNA-guided approach could reduce the use of ACT without compromising 2-year recurrence risk.⁶⁰ In the evaluation of 2-year recurrence-free survival (RFS), ctDNA-guided management was noninferior to standard management (93.5% and 92.4%, respectively; absolute difference, 1.1 percentage points; 95% confidence interval [CI], -4.1 to 6.2 [noninferiority margin, -8.5 percentage points]) illustrating that the use of ACT can be reduced without compromising 2-year RFS. Furthermore, the updated results for this trial were published in 2025 when the RFS and overall survival (OS) data was mature with sufficient follow-up and demonstrated that the 5-year RFS and OS were comparable for both ctDNA-guided and SOC groups and corroborated the results of the early analysis.⁶¹

Tie et al (2025) presented an oral abstract of early results for the randomized AGITG DYNAMIC-III clinical trial that further corroborated the results of the DYNAMIC trial with the 2-year RFS for

ctDNA informed and SOC cohorts were comparable (hazard ratio [HR]: 1.09, 90% CI 0.78 to 1.53; $p=.7$).⁶²

Limitations for this study are listed in Table 5 and 6.

Table 5. Study Relevance Limitations

Study	Population ^a	Intervention ^b	Comparator ^c	Outcomes ^d	Duration of Follow-Up ^e
Tie et al (2022) ⁶⁰ ,	4. Diversity of the population was not reported.	1. ctDNA concentration thresholds to determine a positive result were not defined.			

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

^a Population key: 1. Intended use population unclear; 2. Study population is unclear; 3. Study population not representative of intended use; 4. Enrolled populations do not reflect relevant diversity; 5. Other.

^b Intervention key: 1. Classification thresholds not defined; 2. Version used unclear; 3. Not intervention of interest.

^c Comparator key: 1. Classification thresholds not defined; 2. Not compared to credible reference standard; 3. Not compared to other tests in use for same purpose.

^d Outcomes key: 1. Study does not directly assess a key health outcome; 2. Evidence chain or decision model not explicated; 3. Key clinical validity outcomes not reported (sensitivity, specificity and predictive values); 4.

Reclassification of diagnostic or risk categories not reported; 5. Adverse events of the test not described (excluding minor discomforts and inconvenience of venipuncture or noninvasive tests).

^e Follow-Up key: 1. Follow-up duration not sufficient with respect to natural history of disease (true positives, true negatives, false positives, false negatives cannot be determined).

Table 6. Study Design and Conduct Limitations

Study	Selection ^a	Blinding ^b	Delivery of Test ^c	Selective Reporting ^d	Data Completeness ^e	Statistical ^f
Tie et al (2022) ⁶⁰ ,			3. Procedure for interpreting a positive test were not described			

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

^a Selection key: 1. Selection not described; 2. Selection not random or consecutive (ie, convenience).

^b Blinding key: 1. Not blinded to results of reference or other comparator tests.

^c Test Delivery key: 1. Timing of delivery of index or reference test not described; 2. Timing of index and comparator tests not same; 3. Procedure for interpreting tests not described; 4. Expertise of evaluators not described.

^d Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.

^e Data Completeness key: 1. Inadequate description of indeterminate and missing samples; 2. High number of samples excluded; 3. High loss to follow-up or missing data.

^f Statistical key: 1. Confidence intervals and/or p values not reported; 2. Comparison to other tests not reported.

CIRCULATING TUMOR CELLS

Chain of Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs.

Indirect evidence on clinical utility rests on clinical validity. If the evidence is insufficient to demonstrate test performance, no inferences can be made about clinical utility.

A chain of evidence to demonstrate clinical utility requires an evidence-based management pathway. There is not an explicated, evidence-based management pathway for the use of CTCs to guide early treatment before relapse.

No trials were identified demonstrating that treatment before relapse based on changes in CTCs improves patient outcomes.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. Smerage et al (2014) reported on the results of an RCT of patients with metastatic breast cancer and persistently increased CTC levels to test whether changing chemotherapy after 1 cycle of first-line therapy could improve overall survival (OS; the primary study outcome).⁶³ Patients who did not have increased CTC levels at baseline remained on initial therapy until progression (arm A), patients with initially increased CTC levels that decreased after 21 days of therapy remained on initial therapy (arm B), and patients with persistently increased CTC levels after 21 days of therapy were randomized to continue initial therapy (arm C1) or change to an alternative chemotherapy (arm C2). There were 595 eligible and evaluable patients, 276 (46%) of whom did not have increased CTC levels (arm A). Of patients with initially increased CTC levels, 31 (10%) were not retested, 165 were assigned to arm B, and 123 were randomized to arms C1 or C2. There was no difference in median OS between arms C1 (10.7 months) and C2 (12.5 months; p=.98). Circulating tumor cell levels were strongly prognostic, with a median OS for arms A, B, and C (C1 and C2 combined) of 35 months, 23 months, and 13 months, respectively (p<.001). This trial showed the prognostic significance of CTCs in patients, which rests on clinical validity. If the evidence is insufficient to demonstrate test performance, no inferences can be made about clinical utility.

The evidence is insufficient to demonstrate test performance for currently available CTC tests; therefore, no inferences can be made about clinical utility through a chain of evidence.

Section Summary: Monitoring Treatment Response in Cancer

For indications reviewed herein, there is only one RCT with direct evidence that for ctDNA to monitoring treatment response may improve the net health outcome compared with standard methods. However, there were some notable limitations from the RCTs that preclude any conclusions on whether testing for ctDNA leads to better net health outcomes compared to standard methods. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For indications reviewed herein, there is no direct evidence that using CTCs to monitor treatment response improves the net health outcome compared with standard methods. Given the breadth of methodologies available to assess CTCs, the clinical validity of each commercially available test must be established independently, and these data are lacking. The evidence is insufficient to demonstrate test performance for currently available CTC tests that are reviewed herein; therefore, no inferences can be made about clinical utility through a chain of evidence.

Section Summary: Predicting Risk of Relapse

For indications reviewed herein, there is no direct evidence that using ctDNA to predict the risk of relapse improves the net health outcome compared with standard methods. Furthermore, the RCTs that assessed the clinical validity of ctDNA testing have demonstrated that ctDNA levels correlate with worse clinical outcomes, but further studies are needed to establish threshold metrics for predicting the risk of relapse for individuals with cancer. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For indications reviewed herein, there is no direct evidence that using CTCs to predict the risk of relapse improves the net health outcome compared with standard methods. Given the breadth of methodologies available to assess CTCs, the clinical validity of each commercially available test must be established independently, and these data are lacking. The evidence is insufficient to demonstrate test performance for currently available CTC tests that are reviewed herein; therefore, no inferences can be made about clinical utility through a chain of evidence.

SUPPLEMENTAL INFORMATION

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Practice Guidelines and Position Statements

Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a US professional society, an international society with US representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

American Society of Clinical Oncology

In 2022, the American Society of Clinical Oncology (ASCO) published a Provisional Clinical Opinion on somatic genetic testing in individuals with metastatic or advanced cancer.⁶⁴ The Opinion addressed circulating tumor DNA (ctDNA) testing under additional topics but did not include a specific statement with a strength of recommendation rating. The panel noted, "There is a growing body of evidence on the clinical utility of genomic testing on cfDNA in the plasma," citing the systematic review conducted by Merker et al (2018)³. The panel also noted that ASCO will update that systematic review over the next few years.

The discussion also included the following points:

- "In patients without tissue-based genomic test results, treatment may be based on actionable alterations identified in cfDNA."
- "Testing is most helpful when genomic testing is indicated, archival tissue is unavailable, and new tumor biopsies are not feasible."
- "cfDNA levels themselves may be prognostic and early cfDNA dynamics may serve as an early predictor of therapy response or resistance."

- "Ongoing studies are expected to better delineate the clinical utility of serial liquid biopsies."

In 2022, ASCO published a guideline update on biomarkers for adjuvant endocrine and chemotherapy in early-stage breast cancer.⁶⁵ The following recommendations were issued:

Circulating tumor DNA

- "If a patient has node-negative or node-positive ER-positive, HER2-positive, or TNBC, the clinician should not use ctDNA to guide decisions for adjuvant endocrine and chemotherapy (Type: evidence-based; Evidence quality: intermediate; Strength of recommendation: strong)."

Circulating tumor cells

- "If a patient has node-negative or node-positive ER-positive, HER2-positive, or TNBC, the clinician should not use circulating tumor cells (CTC) to guide decisions for adjuvant endocrine and chemotherapy (Type: evidence-based; Evidence quality: intermediate; Strength of recommendation: strong)"

National Comprehensive Cancer Network

There is no general National Comprehensive Cancer Network (NCCN) guideline on the use of liquid biopsy. Refer to treatment recommendations by cancer type for specific recommendations.

U.S. Preventive Services Task Force Recommendations

Not applicable.

Ongoing and Unpublished Clinical Trials

Some currently ongoing trials that might influence this review are listed in Table 2.

Table 7. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
<i>Ongoing</i>			
NCT06640283	Dynamic Assessment of ctDNA in Patients With Cervical and Anal Canal Tumors to Optimize Follow-up and Clinical Outcomes in the Brazilian Unified Health System (SUS)	150	Jan 2027
NCT06875609	ctDNA Clearance and ctDNA Monitoring Study in Cutaneous Squamous Cell Carcinoma	60	Apr 2028
NCT06225505	Early Detection of Triple Negative Breast Cancer Relapse: a Clinical Utility Phase II Trial	450	Dec 2028
NCT06450314	De-escalation of Medical Therapies in HER2-positive Metastatic Breast Cancer in Long-term Persistent Response and Minimal Residual Disease Undetectable in Circulating Tumor DNA	170	Dec 2029
NCT06561178	Individualized Tumor-Informed Circulating Tumor DNA (ctDNA) Analysis for Monitoring Postoperative Recurrence Following Neoadjuvant Therapy in Esophageal Squamous Cell Carcinoma (NEOCRTEC2401)	50	June 2027

NCT No.	Trial Name	Planned Enrollment	Completion Date
NCT07058519	The Efficacy and Safety of Osimertinib-based Adaptive Treatment Guided by Circulating Tumour DNA (ctDNA) Epidermal Growth Factor Receptor Mutation-positive (EGFRm) Dynamic Monitoring in Locally Advanced or Metastatic EGFRm Non-small Cell Lung Cancer (NSCLC) Participants With ctDNA EGFRm Clearance After First-line Osimertinib Plus Chemotherapy: A Phase II, Multicentre, Prospective Study (Adaptive)	250	Jan 2029
NCT07001085	A Prospective Randomized Trial Assessing the Impact of ctDNA Testing in Patients After Liver Resection or Transplantation Due to Metastases From Colorectal Cancer or Hepatocellular Carcinoma (HCC) on Treatment Strategies and Long-term Survival"	300	Apr 2028
NCT06893133	Personalized ctDNA-MRD in Recurrence Monitoring for Gastric Cancer Patients Undergoing Perioperative Treatment Combined With Curative Surgical Resection	110	Apr 2027
NCT06902272	A Phase 2 Study of Circulating Tumor DNA to Predict Response to Neoadjuvant Treatment and De-escalation Adjuvant Immunotherapy in Early-Stage NSCLC (DNA-PREDICT)	30	June 2029
NCT06283875	A Prospective, Single Center Clinical Study on the Clinical Significance of Personalized ctDNA-MRD in Predicting the Efficacy and Monitoring the Risk of Recurrence of Cervical Cancer	80	Jan 2029
NCT06490536	A Precision Medicine Trial Leveraging Blood-Based Tumor Genomics to Optimize Treatment in Operable Stage III and High-Risk Stage II Colon Cancer Patients	700	Sept 2028
NCT06614647	RESPONSE: Colorectal Cancer Survivors' Follow-up Care - Now Digital and Need-based: a National Interventional Effectiveness Trial for Stage I and II Patients	400	Feb 2030
NCT06606028	Tumor-informed ctDNA Testing for Minimal Residual Disease Monitoring Following Curative-intent Treatment of Squamous Cell Carcinoma of the Head and Neck	200	Dec 2029
NCT07035587	Diagnosis of Multiple Cancer and Monitoring of Minimal Residual Tumors After Treatment Using Blood and High-Sensitivity Genetic Analysis Techniques	1200	July 2027
NCT07080021	A Prospective Observational Cohort Study on Longitudinal Monitoring of ctDNA MRD in Neoadjuvant Therapy for Pancreatic Cancer	119	Nov 2027
NCT07057102	Applications of Multiple Omics Sequencing Technologies in Predicting the Efficacy and Monitoring the Recurrence of Non-Small Cell Lung Cancer: A Prospective, Non-Interventional Study	40	Dec 2027

NCT No.	Trial Name	Planned Enrollment	Completion Date
NCT06653127	Evaluation of Circulating Tumor Mitochondrial DNA (ct-mtDNA) As a Biomarker for Minimal Residual Disease (MRD) Assessment and Recurrence Monitoring in Post-treatment Biliary Tract Cancer (BTC)	50	July 2026
NCT06479070	Prognostic Value of Measuring Circulating Tumor DNA in a Cohort of Patients With Stage III and IV UADT Cancer, Treated With Curative RADiOtherapy With or Without Concomitant Treatment.	188	Sep 2029
NCT06090214	Circulating Tumor Cells for the Diagnosis of Intestinal-type Adenocarcinoma of the Ethmoid : a Pilot Study	42	Dec 2025
NCT02889978 ^a	The Circulating Cell-free Genome Atlas Study	15254	Mar 2024 (status unknown)
NCT03957564	Liquid Biopsy in Monitoring the Neoadjuvant Chemotherapy and Operation in Patients With Resectable or Locally Advanced Gastric or Gastro-oesophageal Junction Cancer	40	May 2024 (status unknown)
NCT05582122	SURVEILLE-HPV: National, Multicenter, Open-label, Randomized, Phase II Study Evaluating HPV16 Circulating DNA as Biomarker to Detect the Recurrence, in Order to Improve Post Therapeutic Surveillance of HPV16-driven Oropharyngeal Cancers	420	Apr 2031
NCT05764044	Adjuvant Chemotherapy in Cell-free Human Papillomavirus Deoxyribonucleic Acid (cfHPV-DNA) Plasma Positive Patients: A Biomarker In Locally Advanced Cervical Cancer (CC)	365	Dec 2026

^aDenotes industry sponsored or co-sponsored trial.

NCT: national clinical trial.

CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. This may not be a comprehensive list of procedure codes applicable to this policy.

Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

The code(s) listed below are medically necessary ONLY if the procedure is performed according to the "Policy" section of this document.

CPT/HCPCS	
81400	Molecular Pathology Procedure, Level 1 (Eg, Identification Of Single Germline Variant [Eg, Snp] By Techniques Such As Restriction Enzyme Digestion Or Melt Curve Analysis)
81401	Molecular Pathology Procedure, Level 2 (Eg, 2-10 Snps, 1 Methylated Variant, Or 1 Somatic Variant [Typically Using Nonsequencing Target Variant Analysis], Or Detection Of A Dynamic Mutation Disorder/Triplet Repeat)
81402	Molecular Pathology Procedure, Level 3 (Eg, >10 Snps, 2-10 Methylated Variants, Or 2-10 Somatic Variants [Typically Using Non-Sequencing Target Variant Analysis], Immunoglobulin And T-Cell Receptor Gene Rearrangements, Duplication/Deletion Variants Of 1 Exon)
81403	Molecular pathology procedure, level 4 (e.g., analysis of single exon by DNA sequence analysis, analysis of >10 amplicons using multiplex pcr in 2 or more independent reactions, mutation scanning or duplication/deletion variants of 2-5 exons)
81404	Molecular Pathology Procedure, Level 5 (Eg, Analysis Of 2-5 Exons By DNA Sequence Analysis, Mutation Scanning Or Duplication/Deletion Variants Of 6-10 Exons, Or Characterization Of A Dynamic Mutation Disorder/Triplet Repeat By Southern Blot Analysis)
81405	Molecular Pathology Procedure, Level 6 (Eg, Analysis Of 6-10 Exons By DNA Sequence Analysis, Mutation Scanning Or Duplication/Deletion Variants Of 11-25 Exons, Regionally Targeted Cytogenomic Array Analysis)
81406	Molecular Pathology Procedure, Level 7 (Eg, Analysis Of 11-25 Exons By DNA Sequence Analysis, Mutation Scanning Or Duplication/Deletion Variants Of 26-50 Exons)
81407	Molecular Pathology Procedure, Level 8 (Eg, Analysis Of 26-50 Exons By DNA Sequence Analysis, Mutation Scanning Or Duplication/Deletion Variants Of >50 Exons, Sequence Analysis Of Multiple Genes On One Platform)
81408	Molecular Pathology Procedure, Level 9 (Eg, Analysis Of >50 Exons In A Single Gene By DNA Sequence Analysis)
81479	Unlisted Molecular Pathology Procedure
86152	Cell Enumeration Using Immunologic Selection And Identification In Fluid Specimen (Eg, Circulating Tumor Cells In Blood);

CPT/HCPGs	
86153	Cell Enumeration Using Immunologic Selection And Identification In Fluid Specimen (Eg, Circulating Tumor Cells In Blood); Physician Interpretation And Report, When Required
0091U	Oncology (Colorectal) Screening, Cell Enumeration Of Circulating Tumor Cells, Utilizing Whole Blood, Algorithm, For The Presence Of Adenoma Or Cancer, Reported As A Positive Or Negative Result
0242U	Targeted genomic sequence analysis panel, solid organ neoplasm, cell free circulating DNA analysis of 55-74 genes, interrogation for sequence variants, gene copy number amplifications, and gene rearrangements
0338U	Oncology (solid tumor), circulating tumor cell selection, identification, morphological characterization, detection and enumeration based on differential EpCAM, cytokeratins 8, 18, and 19, and CD45 protein biomarkers, and quantification of HER2 protein biomarker-expressing cells, peripheral blood. CellSearch® HER2 Circulating Tumor Cell

REVISIONS	
01-27-2021	New Policy added to the bcbsks.com web site.
04-01-2021	In Coding section: <ul style="list-style-type: none"> Added CPT code 0242U
01-04-2022	Updated Description Section
	Updated Rationale Section
	Updated References Section
09-27-2022	Updated Description Section
	Updated Rationale Section
	Updated Coding Section <ul style="list-style-type: none"> Added 0338U (effective 10-01-2022)
	Updated References Section
01-03-2023	Updated Coding Section <ul style="list-style-type: none"> Added 0357U (eff. 01-01-2023)
10-02-2023	Updated Descriptions Section
	Updated Policy Section <ul style="list-style-type: none"> Added "not otherwise addressed in policy guidelines." at the end of the statement
	Updated Policy Guidelines <ul style="list-style-type: none"> Changed to read: "This policy does not address the use of blood-based testing (liquid biopsy) to select targeted treatment for breast cancer, non-small cell lung cancer, melanoma/glioma, ovarian cancer, pancreatic cancer, and prostate cancer, the use of liquid biopsy to select immune checkpoint inhibitor therapy, tumor-Informed circulating tumor DNA testing for cancer management, comprehensive genomic profiling for selecting targeted cancer therapies, the use of blood-based testing for detection or risk assessment of prostate cancer; or the use of AR-V7 circulating tumor cells for metastatic prostate cancer."
	Updated Rationale Section
	Updated Coding Section <ul style="list-style-type: none"> Removed ICD-10 Diagnoses Box Removed deleted code 0357U (eff. 10-01-2023)
	Updated References Section
	Updated Descriptions Section
10-08-2024	

	Updated Rationale Section
	Updated References Section
01-05-2026	Updated Description Section
	Updated Rationale Section
	Updated Reference Section

REFERENCES

1. Alix-Panabières C, Pantel K. Clinical Applications of Circulating Tumor Cells and Circulating Tumor DNA as Liquid Biopsy. *Cancer Discov.* May 2016; 6(5): 479-91. PMID 26969689
2. Food & Drug Administration. 2025. List of Cleared or Approved Companion Diagnostic Devices (In Vitro and Imaging Tools). <https://www.fda.gov/medical-devices/in-vitro-diagnostics/list-cleared-or-approved-companion-diagnostic-devices-in-vitro-and-imaging-tools>. Accessed October 27, 2025
3. Merker JD, Oxnard GR, Compton C, et al. Circulating Tumor DNA Analysis in Patients With Cancer: American Society of Clinical Oncology and College of American Pathologists Joint Review. *J Clin Oncol.* Jun 01 2018; 36(16): 1631-1641. PMID 29504847
4. Pascual J, Attard G, Bidard FC, et al. ESMO recommendations on the use of circulating tumour DNA assays for patients with cancer: a report from the ESMO Precision Medicine Working Group. *Ann Oncol.* Aug 2022; 33(8): 750-768. PMID 35809752
5. Ruiz-Vico M, Wetterskog D, Orlando F, et al. Liquid Biopsy in Progressing Prostate Cancer Patients Starting Docetaxel with or Without Enzalutamide: A Biomarker Study of the PRESIDE Phase 3b Trial. *Eur Urol Oncol.* Feb 2025; 8(1): 135-144. PMID 39261236
6. LaPelusa M, Qiao W, Iorgulescu B, et al. Long-Term Efficacy of Pembrolizumab and the Clinical Utility of ctDNA in Locally Advanced dMMR/MSI-H Solid Tumors. *Nat Commun.* May 15 2025; 16(1): 4514. PMID 40374594
7. Rodrigues M, Ramtohul T, Rampanou A, et al. Prospective assessment of circulating tumor DNA in patients with metastatic uveal melanoma treated with tebentafusp. *Nat Commun.* Oct 14 2024; 15(1): 8851. PMID 39402032
8. Knutson TP, Luo B, Kobilka A, et al. AR alterations inform circulating tumor DNA detection in metastatic castration resistant prostate cancer patients. *Nat Commun.* Dec 11 2024; 15(1): 10648. PMID 39663356
9. Han JY, Ahn MJ, Lee KH, et al. Updated overall survival and ctDNA analysis in patients with EGFR T790M-positive advanced non-small cell lung cancer treated with lazertinib in the phase 1/2 LASER201 study. *BMC Med.* Oct 08 2024; 22(1): 428. PMID 39379931
10. Herbst RS, John T, Grohé C, et al. Molecular residual disease analysis of adjuvant osimertinib in resected EGFR-mutated stage IB-IIIA non-small-cell lung cancer. *Nat Med.* Jun 2025; 31(6): 1958-1968. PMID 40097663
11. Syeda MM, Long GV, Garrett J, et al. Clinical validation of droplet digital PCR assays in detecting BRAF V600 -mutant circulating tumour DNA as a prognostic biomarker in patients with resected stage III melanoma receiving adjuvant therapy (COMBI-AD): a biomarker analysis from a double-blind, randomised phase 3 trial. *Lancet Oncol.* May 2025; 26(5): 641-653. PMID 40250457
12. Ademuyiwa FO, Ma CX, Weilbaecher K, et al. Detection of Circulating Tumor DNA Using a Tissue-Free Epigenomic Assay Is a Highly Prognostic Biomarker in Early-Stage Triple-Negative Breast Cancer. *Clin Cancer Res.* Jun 03 2025; 31(11): 2173-2182. PMID 40116350

13. Yoo C, Jeong H, Jeong JH, et al. Circulating tumor DNA status and dynamics predict recurrence in patients with resected extrahepatic cholangiocarcinoma. *J Hepatol.* May 2025; 82(5): 861-870. PMID 39532185
14. Taieb J, Souglakos J, Boukovinas I, et al. Combined Analyses of Circulating Tumor DNA and Immunoscore in Patients With Stage III Colon Cancer: A Post Hoc Analysis of the PRODIGE-GERCOR IDEA-France/HORG-IDEA-Greece Trials. *J Clin Oncol.* May 2025; 43(13): 1564-1577. PMID 39903903
15. Mayadev J, Vázquez Limón JC, Ramírez Godínez FJ, et al. Ultrasensitive detection and tracking of circulating tumor DNA to predict relapse and survival in patients with locally advanced cervical cancer: phase III CALLA trial analyses. *Ann Oncol.* Sep 2025; 36(9): 1047-1057. PMID 40500687
16. Long GV, Tang H, Desai K, et al. Pretreatment and on-treatment ctDNA and tissue biomarkers predict recurrence in patients with stage IIIB-D/IV melanoma treated with adjuvant immunotherapy: CheckMate 915. *J Immunother Cancer.* Jul 11 2025; 13(7). PMID 40645660
17. Azaïs H, Brochard C, Taly V, et al. Prognostic value of circulating tumor DNA at diagnosis and its early decrease after one cycle of neoadjuvant chemotherapy for patients with advanced epithelial ovarian cancer. An ancillary analysis of the CHIVA phase II GINECO trial. *Gynecol Oncol.* Jan 2025; 192: 145-154. PMID 39671779
18. Shen T, Li T, Cao Y, et al. Circulating tumor DNA as a biomarker for progression and survival in esophageal cancer after neoadjuvant therapy and esophagectomy: a systematic review and meta-analysis. *Int J Surg.* Aug 12 2025; 111(11): 8515-22. PMID 40793951
19. Niu S, Sun T, Wang M, et al. Multiple time points for detecting circulating tumor DNA to monitor the response to neoadjuvant therapy in breast cancer: a meta-analysis. *BMC Cancer.* Jan 22 2025; 25(1): 115. PMID 39844103
20. Zhang D, Jahanfar S, Rabinowitz JB, et al. Role of circulating tumor DNA in early-stage triple-negative breast cancer: a systematic review and meta-analysis. *Breast Cancer Res.* Mar 12 2025; 27(1): 38. PMID 40075528
21. Leite da Silva LF, Saldanha EF, de Menezes JSA, et al. Plasma ctDNA kinetics as a predictor of systemic therapy response for advanced non-small cell lung cancer: a systematic review and meta-analysis. *Oncologist.* Feb 06 2025; 30(2). PMID 39998904
22. Kazemi-Harikande SZ, Salmani Jelodar MR, Roshandel G, et al. The prognostic role of circulating DNA markers in patients with lung malignancies: a systematic review and meta-analysis. *Biomark Med.* Aug 2025; 19(16): 793-806. PMID 40825939
23. Che S, Yu D. Predictive role of circulating tumor DNA based molecular residual disease for long-term outcomes in non-small cell lung cancer patients: a meta-analysis. *World J Surg Oncol.* Jun 13 2025; 23(1): 235. PMID 40514661
24. Zhang C, Zhao H, Shi Q. Postoperative Circulating Tumour DNA in Predicting Recurrence of Non-small Cell Lung Cancer: A Systematic Review and Meta-analysis. *Clin Oncol (R Coll Radiol).* Aug 2025; 44: 103892. PMID 40614309
25. Zhou Q, Chen X, Zeng B, et al. Circulating tumor DNA as a biomarker of prognosis prediction in colorectal cancer: a systematic review and meta-analysis. *J Natl Cancer Cent.* Apr 2025; 5(2): 167-178. PMID 40265088
26. Hoang T, Choi MK, Oh JH, et al. Utility of circulating tumor DNA to detect minimal residual disease in colorectal cancer: A systematic review and network meta-analysis. *Int J Cancer.* Aug 15 2025; 157(4): 722-740. PMID 40293388

27. Holz A, Paul B, Zapf A, et al. Circulating tumor DNA as prognostic marker in patients with metastatic colorectal cancer undergoing systemic therapy: A systematic review and meta-analysis. *Cancer Treat Rev.* Sep 2025; 139: 102999. PMID 40743933
28. Negro S, Pulvirenti A, Trento C, et al. Circulating Tumor DNA as a Real-Time Biomarker for Minimal Residual Disease and Recurrence Prediction in Stage II Colorectal Cancer: A Systematic Review and Meta-Analysis. *Int J Mol Sci.* Mar 11 2025; 26(6). PMID 40141130
29. Fiorica F, Mandarà M, Giuliani J, et al. Circulating DNA in Rectal Cancer to Unravel the Prognostic Potential for Radiation Oncologist: A Meta-analysis. *Am J Clin Oncol.* Feb 01 2025; 48(2): 83-91. PMID 39439084
30. Liu L, Hou S, Zhu A, et al. The prognostic value of circulating tumor DNA in malignant melanoma patients treated with immune checkpoint inhibitors: a systematic review and meta-analysis. *Front Immunol.* 2024; 15: 1520441. PMID 39896816
31. Noronha MM, da Silva LFL, Almeida LFC, et al. Prognostic and Predictive Value of ctDNA for Metastatic Uveal Melanoma: A Systematic Review and Meta-Analysis. *Pigment Cell Melanoma Res.* Sep 2025; 38(5): e70047. PMID 40799039
32. Zhao X, Hou S, Hao R, et al. Prognostic significance of circulating tumor DNA detection and quantification in cervical cancer: a systematic review and meta-analysis. *Front Oncol.* 2025; 15: 1566750. PMID 40255423
33. Yang R, Li T, Zhang S, et al. The effect of circulating tumor DNA on the prognosis of patients with head and neck squamous cell carcinoma: a systematic review and meta-analysis. *BMC Cancer.* Nov 21 2024; 24(1): 1434. PMID 39574043
34. Ma Q, Hou S, Ma H, et al. Prognostic significance of circulating tumor DNA in urothelial carcinoma patients undergoing immune checkpoint inhibitor therapy: a systematic review and meta-analysis. *Front Immunol.* 2025; 16: 1574449. PMID 40364842
35. Gao X, Qi W, Li J, et al. Prognostic and predictive role of circulating tumor DNA detection in patients with muscle invasive bladder cancer: a systematic review and meta-analysis. *Cancer Cell Int.* Mar 01 2025; 25(1): 75. PMID 40025568
36. Zulfiqar A, Liliana B, Mataho NL, et al. The Use of Circulating Tumor Cells in T1 Stage Non-muscle Invasive Bladder Cancer: A Systematic Review and Meta-Analysis. *Urol Res Pract.* Apr 04 2025; 50(6): 343-350. PMID 40243380
37. Matheus GTFU, Ribeiro DM, Menegat ALRS, et al. Prognostic Significance of Circulating Tumor DNA Mutations in Gastrointestinal Stromal Tumors: A Systematic Review and Meta-analysis Based on Time-To-Event Data. *J Gastrointest Cancer.* Jul 15 2025; 56(1): 153. PMID 40665034
38. Sogbe M, Aliseda D, Sangro P, et al. Prognostic value of circulating tumor DNA in different cancer types detected by ultra-low-pass whole-genome sequencing: a systematic review and patient-level survival data meta-analysis. *Carcinogenesis.* Jan 20 2025; 46(1). PMID 39549302
39. Chiang AC, Madison RW, Assaf ZJ, et al. Real-World Validity of Tissue-Agnostic Circulating Tumor DNA Response Monitoring in Lung Cancers Treated With Chemotherapy, Immunotherapy, or Targeted Agents. *JTO Clin Res Rep.* Sep 2025; 6(9): 100829. PMID 40746669
40. Mazel M, Jacot W, Pantel K, et al. Frequent expression of PD-L1 on circulating breast cancer cells. *Mol Oncol.* Nov 2015; 9(9): 1773-82. PMID 26093818
41. Lv Q, Gong L, Zhang T, et al. Prognostic value of circulating tumor cells in metastatic breast cancer: a systemic review and meta-analysis. *Clin Transl Oncol.* Mar 2016; 18(3): 322-30. PMID 26260915

42. Wang CH, Chang CJ, Yeh KY, et al. The Prognostic Value of HER2-Positive Circulating Tumor Cells in Breast Cancer Patients: A Systematic Review and Meta-Analysis. *Clin Breast Cancer*. Aug 2017; 17(5): 341-349. PMID 28347604
43. Zhang L, Riethdorf S, Wu G, et al. Meta-analysis of the prognostic value of circulating tumor cells in breast cancer. *Clin Cancer Res*. Oct 15 2012; 18(20): 5701-10. PMID 22908097
44. Huang X, Gao P, Song Y, et al. Relationship between circulating tumor cells and tumor response in colorectal cancer patients treated with chemotherapy: a meta-analysis. *BMC Cancer*. Dec 18 2014; 14: 976. PMID 25519477
45. Groot Koerkamp B, Rahbari NN, Büchler MW, et al. Circulating tumor cells and prognosis of patients with resectable colorectal liver metastases or widespread metastatic colorectal cancer: a meta-analysis. *Ann Surg Oncol*. Jul 2013; 20(7): 2156-65. PMID 23456317
46. Fan JL, Yang YF, Yuan CH, et al. Circulating Tumor Cells for Predicting the Prognostic of Patients with Hepatocellular Carcinoma: A Meta Analysis. *Cell Physiol Biochem*. 2015; 37(2): 629-40. PMID 26344495
47. Ma X, Xiao Z, Li X, et al. Prognostic role of circulating tumor cells and disseminated tumor cells in patients with prostate cancer: a systematic review and meta-analysis. *Tumour Biol*. Jun 2014; 35(6): 5551-60. PMID 24563278
48. Wang FB, Yang XQ, Yang S, et al. A higher number of circulating tumor cells (CTC) in peripheral blood indicates poor prognosis in prostate cancer patients--a meta-analysis. *Asian Pac J Cancer Prev*. 2011; 12(10): 2629-35. PMID 22320965
49. de Bono J., Scher HI, Montgomery RB, et al. Circulating tumor cells predict survival benefit from treatment in metastatic castration-resistant prostate cancer. *Clin Cancer Res*. 2008;14(19):6302-6309. PMID
50. Sun T, Zou K, Yuan Z, et al. Clinicopathological and prognostic significance of circulating tumor cells in patients with head and neck cancer: a meta-analysis. *Onco Targets Ther*. 2017; 10: 3907-3916. PMID 28831265
51. Li Q, Ai L, Zuo L, et al. Circulating plasma cells as a predictive biomarker in Multiple myeloma: an updated systematic review and meta-analysis. *Ann Med*. Dec 2024; 56(1): 2338604. PMID 38599340
52. Mocellin S, Hoon D, Ambrosi A, et al. The prognostic value of circulating tumor cells in patients with melanoma: a systematic review and meta-analysis. *Clin Cancer Res*. Aug 01 2006; 12(15): 4605-13. PMID 16899608
53. Rack B, Schindlbeck C, Jückstock J, et al. Circulating tumor cells predict survival in early average-to-high risk breast cancer patients. *J Natl Cancer Inst*. May 15 2014; 106(5). PMID 24832787
54. Thalgott M, Rack B, Horn T, et al. Detection of Circulating Tumor Cells in Locally Advanced High-risk Prostate Cancer During Neoadjuvant Chemotherapy and Radical Prostatectomy. *Anticancer Res*. Oct 2015; 35(10): 5679-85. PMID 26408743
55. Denève E, Riethdorf S, Ramos J, et al. Capture of viable circulating tumor cells in the liver of colorectal cancer patients. *Clin Chem*. Sep 2013; 59(9): 1384-92. PMID 23695297
56. Rink M, Chun FK, Dahlem R, et al. Prognostic role and HER2 expression of circulating tumor cells in peripheral blood of patients prior to radical cystectomy: a prospective study. *Eur Urol*. Apr 2012; 61(4): 810-7. PMID 22277196
57. Gazzaniga P, de Berardinis E, Raimondi C, et al. Circulating tumor cells detection has independent prognostic impact in high-risk non-muscle invasive bladder cancer. *Int J Cancer*. Oct 15 2014; 135(8): 1978-82. PMID 24599551

58. Schulze K, Gasch C, Staufer K, et al. Presence of EpCAM-positive circulating tumor cells as biomarker for systemic disease strongly correlates to survival in patients with hepatocellular carcinoma. *Int J Cancer*. Nov 2013; 133(9): 2165-71. PMID 23616258
59. Vashist YK, Effenberger KE, Vettorazzi E, et al. Disseminated tumor cells in bone marrow and the natural course of resected esophageal cancer. *Ann Surg*. Jun 2012; 255(6): 1105-12. PMID 22580852
60. Tie J, Cohen JD, Lahouel K, et al. Circulating Tumor DNA Analysis Guiding Adjuvant Therapy in Stage II Colon Cancer. *N Engl J Med*. Jun 16 2022; 386(24): 2261-2272. PMID 35657320
61. Tie J, Wang Y, Lo SN, et al. Circulating tumor DNA analysis guiding adjuvant therapy in stage II colon cancer: 5-year outcomes of the randomized DYNAMIC trial. *Nat Med*. May 2025; 31(5): 1509-1518. PMID 40055522
62. Tie J, Wang Y, Loree JM, et al. ctDNA-guided adjuvant chemotherapy escalation in stage III colon cancer: Primary analysis of the ctDNA-positive cohort from the randomized AGITG dynamic-III trial (intergroup study of AGITG and CCTG). *J. Clin. Oncol.* 2025; 43(16_suppl):3503, European Society for Medical Oncology (ESMO) Congress 2025, October 2025.
63. Smerage JB, Barlow WE, Hortobagyi GN, et al. Circulating tumor cells and response to chemotherapy in metastatic breast cancer: SWOG S0500. *J Clin Oncol*. Nov 01 2014; 32(31): 3483-9. PMID 24888818
64. Chakravarty D, Johnson A, Sklar J, et al. Somatic Genomic Testing in Patients With Metastatic or Advanced Cancer: ASCO Provisional Clinical Opinion. *J Clin Oncol*. Apr 10 2022; 40(11): 1231-1258. PMID 35175857
65. Andre F, Ismaila N, Allison KH, et al. Biomarkers for Adjuvant Endocrine and Chemotherapy in Early-Stage Breast Cancer: ASCO Guideline Update. *J Clin Oncol*. Jun 01 2022; 40(16): 1816-1837. PMID 35439025
66. Centers for Medicare & Medicaid Services. 2020. National Coverage Determination: Next Generation Sequencing (90.2). <https://www.cms.gov/medicare-coverage-database/view/ncd.aspx?NCDId=372>. Accessed October 27, 2025.

OTHER REFERENCES

1. Blue Cross and Blue Shield of Kansas, Oncology Liaison Committee February 2021, August 2024.
2. Blue Cross and Blue Shield of Kansas, Pathology Liaison Committee May 2021.