

**NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)**

# Colon Cancer

Version 1.2014

**NCCN.org**

**IMPORTANT NOTE REGARDING  
LEUCOVORIN SHORTAGE,  
PLEASE SEE [MS-13](#)**

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# NCCN Guidelines Version 1.2014 Panel Members

## Colon Cancer

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[Discussion](#)

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[NCCN Guidelines Panel Disclosures](#)



### [NCCN Colon Cancer Panel Members](#)

### [Summary of the Guidelines Updates](#)

#### Clinical Presentations and Primary Treatment:

- [Pedunculated polyp \(adenoma \[tubular, tubulovillous, or villous\]\) with invasive cancer \(COL-1\)](#)
- [Sessile polyp \(adenoma \[tubular, tubulovillous, or villous\]\) with invasive cancer \(COL-1\)](#)
- [Colon cancer appropriate for resection \(COL-2\)](#)
- [Suspected or proven metastatic adenocarcinoma \(COL-5\)](#)

#### [Pathologic Stage, Adjuvant Therapy, and Surveillance \(COL-3\)](#)

#### [Recurrence and Workup \(COL-9\)](#)

#### [Principles of Pathologic Review \(COL-A\)](#)

#### [Principles of Surgery \(COL-B\)](#)

#### [Chemotherapy for Advanced or Metastatic Disease \(COL-C\)](#)

#### [Principles of Risk Assessment for Stage II Disease \(COL-D\)](#)

#### [Principles of Adjuvant Therapy \(COL-E\)](#)

#### [Principles of Radiation Therapy \(COL-F\)](#)

#### [Principles of Survivorship \(COL-G\)](#)

### [Staging \(ST-1\)](#)

**Clinical Trials:** NCCN believes that the best management for any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.

To find clinical trials online at NCCN Member Institutions, [click here: nccn.org/clinical\\_trials/physician.html](#).

**NCCN Categories of Evidence and Consensus:** All recommendations are category 2A unless otherwise specified.

See [NCCN Categories of Evidence and Consensus](#)

The NCCN Guidelines® are a statement of evidence and consensus of the authors regarding their views of currently accepted approaches to treatment. Any clinician seeking to apply or consult the NCCN Guidelines is expected to use independent medical judgment in the context of individual clinical circumstances to determine any patient's care or treatment. The National Comprehensive Cancer Network® (NCCN®) makes no representations or warranties of any kind regarding their content, use or application and disclaims any responsibility for their application or use in any way. The NCCN Guidelines are copyrighted by National Comprehensive Cancer Network®. All rights reserved. The NCCN Guidelines and the illustrations herein may not be reproduced in any form without the express written permission of NCCN. ©2013.



Summary of changes in the 1.2014 version of the Colon Cancer Guidelines from the 3.2013 version include:

### [COL-2](#)

- Platelets removed from workup, as they are included with CBC.
- Resectable, obstructing: stent removed as an option.
- Footnote “i” modified with the addition of this sentence, “PET-CT should only be used to evaluate an equivocal finding on a contrast-enhanced CT scan or in patients with strong contraindications to IV contrast.”

### [COL-7](#)

- Bevacizumab added as an option in combination with FOLFOXIRI for unresectable synchronous liver and/or lung metastases. The category designation remains 2B.
- Adjuvant therapy for patients converted to resectable modified: ~~If patient received neoadjuvant therapy, consider observation or shortened course of chemotherapy~~

### [COL-9](#)

- Serial CEA elevation: “Consider PET-CT scan” removed from the workup section.

### [COL-10](#)

- Repeat neoadjuvant therapy changed to reinitiate neoadjuvant therapy.

### [COL-B 1 of 3](#)

- The following criterion removed for laparoscopic-assisted colectomy: There is no disease in the rectum or prohibitive abdominal adhesions.

### [COL-C 1 of 9](#) and [COL-C 2 of 9](#)

- “KRAS mutant only” removed from “Regorafenib” and clarifying footnote 16 added: Regorafenib is a treatment option for patients who have progressed through all available regimens (e.g. KRAS mutant or KRAS WT with previous exposure to anti-EGFR inhibitor.)

### [COL-C 3 of 9](#)

- Bevacizumab added as an option in combination with FOLFOXIRI in initial therapy for advanced or metastatic disease. The category designation remains 2B.

### [COL-C 5 of 9](#)

- Footnote 3, last sentence modified: There are ~~insufficient~~ *no* data to support the routine use of Ca/Mg infusion to prevent oxaliplatin-related neurotoxicity *and therefore should not be done*.
- Footnote 16 added: Regorafenib is a treatment option for patients who have progressed through all available regimens (e.g. KRAS mutant or KRAS WT with previous exposure to anti-EGFR inhibitor.)

### [COL-C 8 of 9](#)

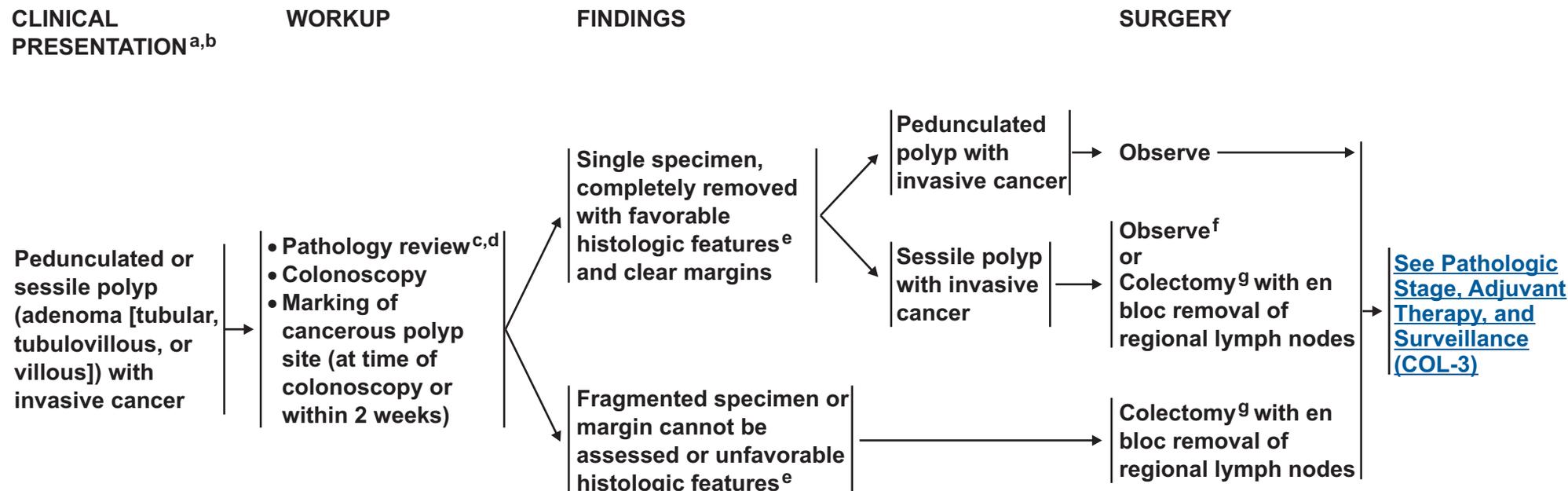
- Regimen information added for bevacizumab in combination with FOLFOXIRI.

### [COL-C 9 of 9](#)

- Reference information added for bevacizumab in combination with FOLFOXIRI.
- Cassidy J, et al. reference replaced with deGramont A, Figer A, Seymour M, et al. Leucovorin and fluorouracil with or without oxaliplatin as first-line treatment in advanced rectal cancer. *J Clin Oncol* 2000;18:2938-2947 and Maindrault-Goebel F, deGramont A, Louvet C, et al. Evaluation of oxaliplatin dose intensity in bimonthly leucovorin and 48-hour 5-fluorouracil continuous infusion regimens (FOLFOX) in pretreated metastatic colorectal cancer. *Annals of Oncology* 2000;11:1477-1483.

### [COL-E 2 of 2](#)

- Cassidy J, et al. reference replaced with Andre T, Boni C, Mounedji-Boudiaf L, et al. Oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment for colon cancer. *N Engl J Med* 2004;350:2343-2351; Cheeseman SL, Joel SP, Chester JD, et al. A 'modified de Gramont' regimen of fluorouracil, alone and with oxaliplatin, for advanced colorectal cancer. *Br J Cancer* 2002;87:393-399; Maindrault-Goebel F, deGramont A, Louvet C, et al. Evaluation of oxaliplatin dose intensity in bimonthly leucovorin and 48-hour 5-fluorouracil continuous infusion regimens (FOLFOX) in pretreated metastatic colorectal cancer. *Annals of Oncology* 2000;11:1477-1483.



<sup>a</sup>Small bowel and appendiceal adenocarcinoma may be treated with systemic chemotherapy according to the NCCN Guidelines for Colon Cancer. Peritoneal mesothelioma and other extrapleural mesotheliomas may be treated with systemic therapy along NCCN Guidelines for Pleural Mesothelioma, as outlined on page [MPM-A](#).

<sup>b</sup>All patients with colon cancer should be counseled for family history and considered for risk assessment. Patients with suspected hereditary non-polyposis colon cancer (HNPCC), familial adenomatous polyposis (FAP), and attenuated FAP, see the [NCCN Guidelines for Colorectal Cancer Screening](#).

<sup>c</sup>Confirm the presence of invasive cancer (pT1). pTis has no biological potential to metastasize.

<sup>d</sup>It has not been established if molecular markers are useful in treatment determination (predictive markers) and prognosis. College of American Pathologists Consensus Statement 1999. Prognostic factors in colorectal cancer. Arch Pathol Lab Med 2000;124:979-994.

<sup>e</sup>[See Principles of Pathologic Review \(COL-A\)](#) - Endoscopically removed malignant polyp.

<sup>f</sup>Observation may be considered, with the understanding that there is significantly greater incidence of adverse outcomes (residual disease, recurrent disease, mortality, hematogenous metastasis, but not lymph node metastasis) than polypoid malignant polyps. [See Principles of Pathologic Review \(COL-A\)](#) - Endoscopically removed malignant polyp.

<sup>g</sup>[See Principles of Surgery \(COL-B 1 of 3\)](#).

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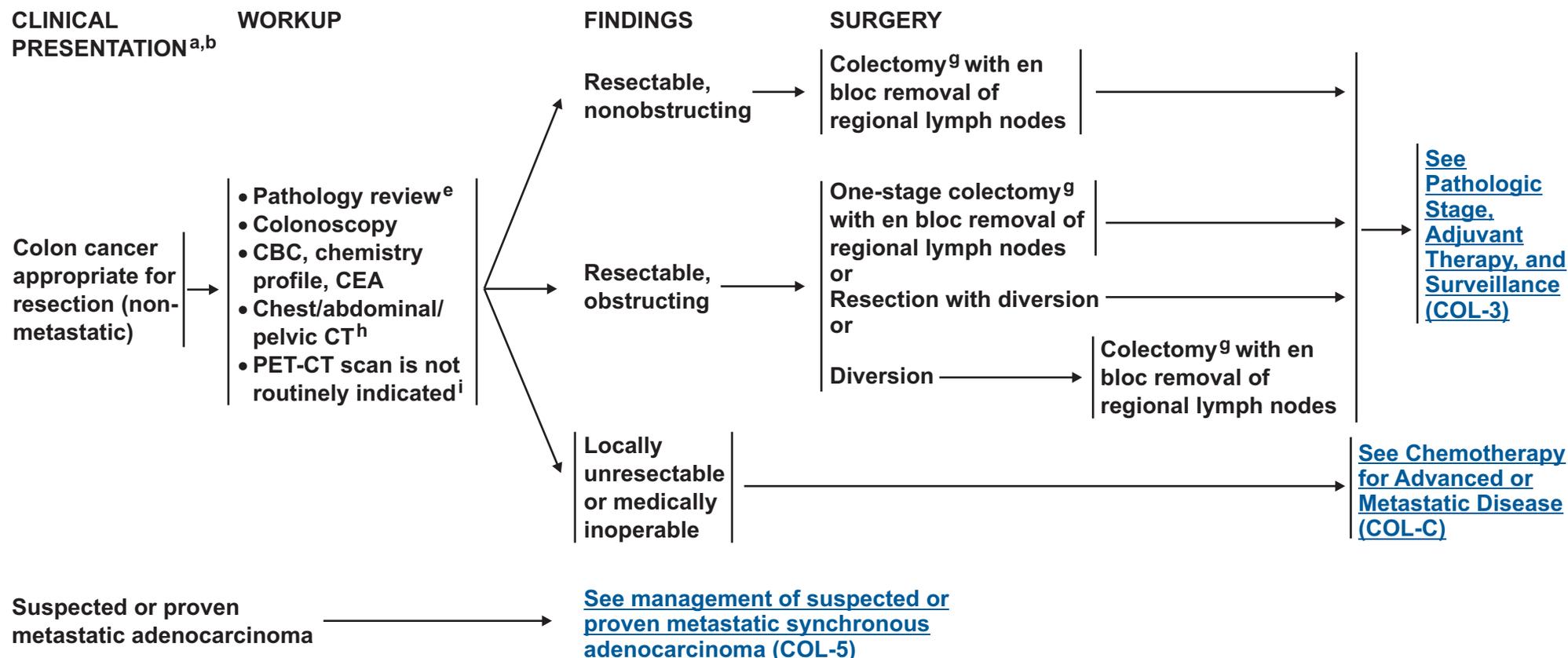
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# NCCN Guidelines Version 1.2014

## Colon Cancer



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<sup>e</sup>[See Principles of Pathologic Review \(COL-A\)](#) - Colon cancer appropriate for resection, pathological stage, and lymph node evaluation.

<sup>g</sup>[See Principles of Surgery \(COL-B 1 of 3\)](#).

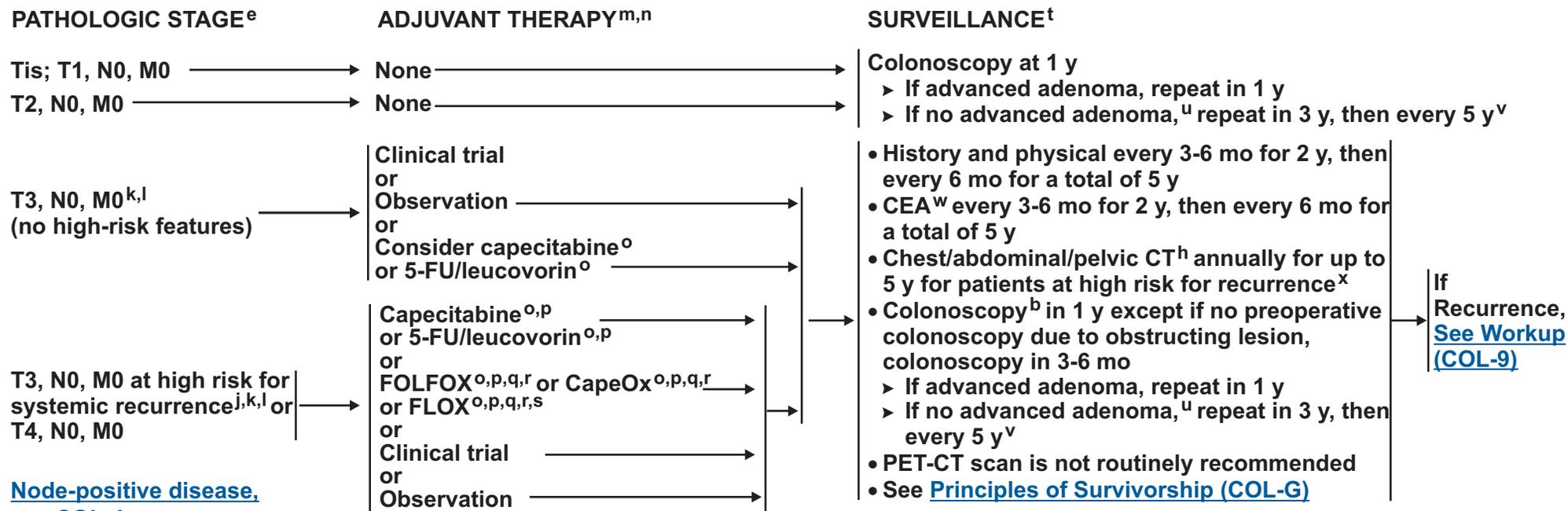
<sup>h</sup>CT should be with IV and oral contrast. Consider abd/pelvic MRI with MRI contrast plus a non-contrast chest CT if either CT of abd/pelvis is inadequate or if patient has a contraindication to CT with IV contrast.

<sup>i</sup>PET-CT does not supplant a contrast-enhanced diagnostic CT scan. PET-CT should only be used to evaluate an equivocal finding on a contrast-enhanced CT scan or in patients with strong contraindications to IV contrast.

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<sup>b</sup>All patients with colon cancer should be counseled for family history and considered for risk assessment. Patients with suspected hereditary non-polyposis colon cancer (HNPCC), familial adenomatous polyposis (FAP), and attenuated FAP, see the [NCCN Guidelines for Colorectal Cancer Screening](#).

<sup>e</sup>See [Principles of Pathologic Review \(COL-A\)](#) - Pathological stage.

<sup>h</sup>CT should be with IV and oral contrast. Consider abd/pelvic MRI with MRI contrast plus a non-contrast chest CT if either CT of abd/pelvis is inadequate or if patient has a contraindication to CT with IV contrast.

<sup>j</sup>High-risk factors for recurrence: poorly differentiated histology (exclusive of those cancers that are MSI-H), lymphatic/vascular invasion, bowel obstruction, <12 lymph nodes examined, perineural invasion, localized perforation, or close, indeterminate, or positive margins. In high-risk stage II patients, there are no data that correlate risk features and selection of chemotherapy.

<sup>k</sup>Testing for mismatch repair (MMR) proteins should be considered for all patients <50 years of age or with stage II disease. Stage II MSI-H patients may have a good prognosis and do not benefit from 5-FU adjuvant therapy. Sargent DJ, Marsoni S, Monges G, et al. Defective mismatch repair as a predictive marker for lack of efficacy of fluorouracil-based adjuvant therapy in colon cancer. *J Clin Oncol* 2010;28:3219-3226. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/20498393>

<sup>l</sup>See [Principles of Risk Assessment for Stage II Disease \(COL-D\)](#).

<sup>m</sup>There are insufficient data to recommend the use of multi-gene assay panels to determine adjuvant therapy.

<sup>n</sup>Bevacizumab, cetuximab, panitumumab, or irinotecan should not be used in the adjuvant setting for stage II or III patients outside the setting of a clinical trial.

<sup>o</sup>See [Principles of Adjuvant Therapy \(COL-E\)](#).

<sup>p</sup>Consider RT for T4 with penetration to a fixed structure. See [Principles of Radiation Therapy \(COL-F\)](#).

<sup>q</sup>A survival benefit has not been demonstrated for the addition of oxaliplatin to 5-FU/leucovorin in stage II colon cancer. Tournigand C, André T, Bonnetain F, et al. Adjuvant therapy with fluorouracil and oxaliplatin in stage II and elderly (between ages 70 and 75 years) with colon cancer: a subgroup analyses of the Multicenter International Study of oxaliplatin, fluorouracil, and leucovorin in the adjuvant treatment of colon cancer trial. *J Clin Oncol* 2012; published online ahead of print on August 20, 2012.

<sup>r</sup>A benefit for the addition of oxaliplatin to 5-FU/leucovorin in patients age 70 and older has not been proven.

<sup>s</sup>Grade 3-4 diarrhea is considerably higher with FLOX than FOLFOX in cross study comparison.

<sup>t</sup>Desch CE, Benson III AB, Somerfield MR, et al. Colorectal cancer surveillance: 2005 update of the American Society of Clinical Oncology Practice Guideline. *J Clin Oncol* 2005;23:8512-8519.

<sup>u</sup>Villous polyp, polyp >1 cm, or high-grade dysplasia.

<sup>v</sup>Rex DK, Kahi CJ, Levin B, et al. Guidelines for colonoscopy surveillance after cancer resection: a consensus update by the American Cancer Society and the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology* 2006;130:1865-71.

<sup>w</sup>If patient is a potential candidate for further intervention.

<sup>x</sup>CT scan may be useful for patients at high risk for recurrence (eg, lymphatic or venous invasion by tumor; poorly differentiated tumors).

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### PATHOLOGIC STAGE<sup>e</sup>

### ADJUVANT THERAPY<sup>m,n,y</sup>

### SURVEILLANCE<sup>t</sup>

T1-3, N1-2, M0  
or T4, N1-2, M0

FOLFOX<sup>o,p,r</sup> or CapeOx<sup>o,p,r</sup>  
(both category 1 and preferred)  
Other options include:  
FLOX (category 1)<sup>o,p,r,s</sup>  
or  
Capecitabine<sup>o,p</sup>  
or  
5-FU/leucovorin<sup>o,p</sup>

- History and physical every 3-6 mo for 2 y, then every 6 mo for a total of 5 y
- CEA<sup>w</sup> every 3-6 mo for 2 y, then every 6 mo for a total of 5 y
- Chest/abdominal/pelvic CT<sup>h</sup> annually for up to 5 y
- Colonoscopy<sup>b</sup> in 1 y except if no preoperative colonoscopy due to obstructing lesion, colonoscopy in 3-6 mo
  - ▶ If advanced adenoma, repeat in 1 y
  - ▶ If no advanced adenoma,<sup>u</sup> repeat in 3 y, then every 5 y<sup>v</sup>
- PET-CT scan is not routinely recommended
- See [Principles of Survivorship \(COL-G\)](#)

If  
Recurrence,  
[See Workup \(COL-9\)](#)

<sup>b</sup>All patients with colon cancer should be counseled for family history and considered for risk assessment. Patients with suspected hereditary non-polyposis colon cancer (HNPCC), familial adenomatous polyposis (FAP), and attenuated FAP, see the [NCCN Guidelines for Colorectal Cancer Screening](#).

<sup>e</sup>See [Principles of Pathologic Review \(COL-A\)](#) - Pathological stage.

<sup>h</sup>CT should be with IV and oral contrast. Consider abd/pelvic MRI with MRI contrast plus a non-contrast chest CT if either CT of abd/pelvis is inadequate or if patient has a contraindication to CT with IV contrast.

<sup>m</sup>There are insufficient data to recommend the use of multi-gene assay panels to determine adjuvant therapy.

<sup>n</sup>Bevacizumab, cetuximab, panitumumab, or irinotecan should not be used in the adjuvant setting for stage II or III patients outside the setting of a clinical trial.

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<sup>r</sup>A benefit for the addition of oxaliplatin to 5-FU/leucovorin in patients age 70 and older has not been proven.

<sup>s</sup>Grade 3-4 diarrhea is considerably higher with FLOX than FOLFOX in cross study comparison.

<sup>t</sup>Desch CE, Benson III AB, Somerfield MR, et al. Colorectal cancer surveillance: 2005 update of the American Society of Clinical Oncology Practice Guideline. J Clin Oncol 2005;23:8512-8519.

<sup>u</sup>Villous polyp, polyp >1 cm, or high-grade dysplasia.

<sup>v</sup>Rex DK, Kahi CJ, Levin B, et al. Guidelines for colonoscopy surveillance after cancer resection: a consensus update by the American Cancer Society and the US Multi-Society Task Force on Colorectal Cancer. Gastroenterology 2006;130:1865-71.

<sup>w</sup>If patient is a potential candidate for further intervention.

<sup>y</sup>Testing for mismatch repair (MMR) proteins should be considered for all patients <50 years of age.

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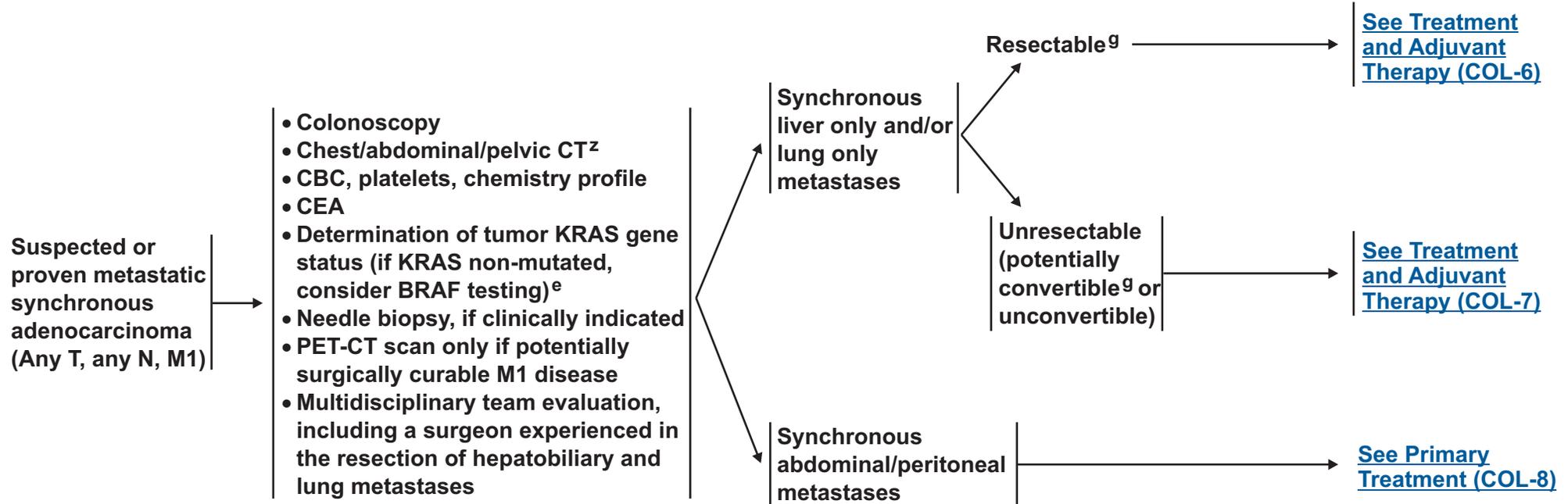
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### CLINICAL PRESENTATION

### WORKUP

### FINDINGS



<sup>e</sup> See Principles of Pathologic Review (COL-A 4 of 5) - KRAS and BRAF Mutation Testing.

<sup>g</sup> See Principles of Surgery (COL-B 2 of 3).

<sup>z</sup> CT should be with IV contrast. Consider MRI with IV contrast if CT is inadequate.

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### TREATMENT

Resectable<sup>9</sup> synchronous liver and/or lung metastases only

Colectomy,<sup>aa</sup> with synchronous or staged liver or lung resection

or  
Neoadjuvant therapy (for 2-3 months) FOLFIRI or FOLFOX or CapeOx<sup>bb</sup> ± bevacizumab<sup>cc</sup> or FOLFIRI or FOLFOX ± panitumumab or FOLFIRI ± cetuximab (KRAS wild-type [WT] gene only)<sup>e,dd</sup> followed by synchronous or staged colectomy<sup>aa</sup> and resection of metastatic disease

or  
Colectomy,<sup>aa</sup> followed by chemotherapy (for 2-3 months) FOLFIRI or FOLFOX or CapeOx<sup>bb</sup> ± bevacizumab<sup>cc</sup> or FOLFIRI or FOLFOX ± panitumumab or FOLFIRI ± cetuximab (KRAS WT gene only)<sup>e,dd</sup> and staged resection of metastatic disease

### ADJUVANT THERAPY<sup>y</sup>

(resected metastatic disease)  
(6 MO PERIOPERATIVE TREATMENT PREFERRED)

FOLFOX/CapeOx preferred

Consider observation or shortened course of chemotherapy

Consider observation or shortened course of chemotherapy

### SURVEILLANCE

If patient stage IV, NED:

- History and physical every 3-6 mo for 2 y, then every 6 mo for a total of 5 y
- CEA every 3-6 mo x 2 y, then every 6 mo x 3-5 y
- Chest/abdominal/pelvic CT<sup>h</sup> scan every 3-6 mo x 2 y, then every 6-12 mo up to a total of 5 y
- Colonoscopy<sup>b</sup> in 1 y except if no preoperative colonoscopy due to obstructing lesion, colonoscopy in 3-6 mo
  - ▶ If advanced adenoma, repeat in 1 y
  - ▶ If no advanced adenoma,<sup>u</sup> repeat in 3 y, then every 5 y<sup>v</sup>

If Recurrence, See Workup (COL-9)

<sup>b</sup>All patients with colon cancer should be counseled for family history and considered for risk assessment. Patients with suspected hereditary non-polyposis colon cancer (HNPCC), familial adenomatous polyposis (FAP), and attenuated FAP, see the [NCCN Guidelines for Colorectal Cancer Screening](#).

<sup>e</sup>See [Principles of Pathologic Review \(COL-A 4 of 5\)](#) - KRAS and BRAF Mutation Testing.

<sup>9</sup>See [Principles of Surgery \(COL-B 2 of 3\)](#).

<sup>h</sup>CT should be with IV and oral contrast. Consider abd/pelvic MRI with MRI contrast plus a non-contrast chest CT if either CT of abd/pelvis is inadequate or if patient has a contraindication to CT with IV contrast.

<sup>u</sup>Villous polyp, polyp >1 cm, or high-grade dysplasia.

<sup>v</sup>Rex DK, Kahi CJ, Levin B, et al. Guidelines for colonoscopy surveillance after cancer resection: a consensus update by the American Cancer Society and the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology* 2006;130(6):1865-71.

<sup>y</sup>Testing for mismatch repair (MMR) proteins should be considered for all patients <50 years of age.

<sup>aa</sup>Hepatic artery infusion ± systemic 5-FU/leucovorin (category 2B) is also an option at institutions with experience in both the surgical and medical oncologic aspects of this procedure.

<sup>bb</sup>The majority of safety and efficacy data for this regimen have been developed in Europe, where a capecitabine starting dose of 1000 mg/m<sup>2</sup> twice daily for 14 days, repeated every 21 days, is standard. Evidence suggests that North American patients may experience greater toxicity with capecitabine (as well as with other fluoropyrimidines) than European patients, and may require a lower dose of capecitabine. The relative efficacy of CapeOx with lower starting doses of capecitabine has not been addressed in large-scale randomized trials.

<sup>cc</sup>The safety of administering bevacizumab pre- or postoperatively, in combination with 5-FU-based regimens, has not been adequately evaluated. There should be at least a 6-week interval between the last dose of bevacizumab and elective surgery and re-initiation of bevacizumab at least 6-8 weeks postoperatively. There is an increased risk of stroke and other arterial events, especially in those aged ≥ 65 years. The use of bevacizumab may interfere with wound healing.

<sup>dd</sup>There are insufficient data to guide the use of anti-EGFR therapy in the first-line setting with active chemotherapy based on BRAF V600E mutation status.

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### TREATMENT

Unresectable<sup>g</sup> synchronous liver and/or lung metastases only

- Systemic therapy (FOLFIRI or FOLFOX or CapeOX<sup>bb</sup> ± bevacizumab<sup>cc</sup> or FOLFIRI or FOLFOX ± panitumumab or FOLFIRI ± cetuximab [KRAS WT gene only]<sup>e,dd</sup> or FOLFOXIRI ± bevacizumab [category 2B])
- Consider colon resection<sup>g</sup> only if imminent risk of obstruction or significant bleeding

Re-evaluate for conversion to resectable<sup>g</sup> every 2 mo if conversion to resectability is a reasonable goal

Converted to resectable  
Remains unresectable

Synchronized or staged resection<sup>g</sup> of colon and metastatic cancer

[See Chemotherapy for Advanced or Metastatic Disease \(COL-C\)](#)

### ADJUVANT THERAPY<sup>y</sup>

(6 MO PERIOPERATIVE TREATMENT PREFERRED)

Active chemotherapy regimen for advanced disease ([See COL-C](#))<sup>aa</sup> (category 2B) or Consider observation or shortened course of chemotherapy

### SURVEILLANCE

If patient stage IV, no evidence of disease (NED):

- History and physical every 3-6 mo x 2 y, then every 6 mo for a total of 5 y
- CEA every 3-6 mo x 2 y, then every 6 mo x 3-5 y
- Chest/abdominal/pelvic CT<sup>h</sup> scan every 3-6 mo x 2 y, then every 6-12 mo up to a total of 5 y
- Colonoscopy<sup>b</sup> in 1 y except if no preoperative colonoscopy due to obstructing lesion, colonoscopy in 3-6 mo
  - If advanced adenoma, repeat in 1 y
  - If no advanced adenoma,<sup>u</sup> repeat in 3 y, then every 5 y<sup>v</sup>

<sup>b</sup>All patients with colon cancer should be counseled for family history and considered for risk assessment. Patients with suspected hereditary non-polyposis colon cancer (HNPCC), familial adenomatous polyposis (FAP), and attenuated FAP, see the [NCCN Guidelines for Colorectal Cancer Screening](#).

<sup>e</sup>[See Principles of Pathologic Review \(COL-A 4 of 5\)](#) - KRAS and BRAF Mutation Testing.

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<sup>y</sup>Testing for mismatch repair (MMR) proteins should be considered for all patients <50 years of age.

<sup>aa</sup>Hepatic artery infusion ± systemic 5-FU/leucovorin (category 2B) is also an option at institutions with experience in both the surgical and medical oncologic aspects of this procedure.

<sup>bb</sup>The majority of safety and efficacy data for this regimen have been developed in Europe, where a capecitabine starting dose of 1000 mg/m<sup>2</sup> twice daily for 14 days, repeated every 21 days, is standard. Evidence suggests that North American patients may experience greater toxicity with capecitabine (as well as with other fluoropyrimidines) than European patients, and may require a lower dose of capecitabine. The relative efficacy of CapeOx with lower starting doses of capecitabine has not been addressed in large-scale randomized trials.

<sup>cc</sup>The safety of administering bevacizumab pre- or postoperatively, in combination with 5-FU-based regimens, has not been adequately evaluated. There should be at least a 6-week interval between the last dose of bevacizumab and elective surgery and re-initiation of bevacizumab at least 6-8 weeks postoperatively. There is an increased risk of stroke and other arterial events, especially in those aged ≥ 65 years. The use of bevacizumab may interfere with wound healing.

<sup>dd</sup>There are insufficient data to guide the use of anti-EGFR therapy in the first-line setting with active chemotherapy based on BRAF V600E mutation status.

**Note:** All recommendations are category 2A unless otherwise indicated.

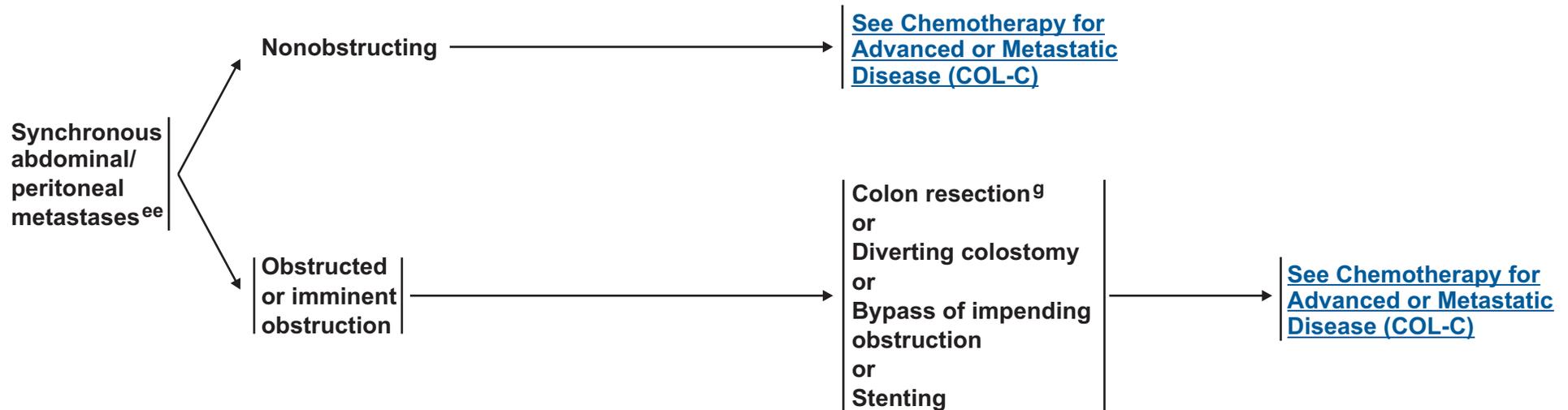
**Clinical Trials:** NCCN believes that the best management of any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.

[See Recurrence \(COL-9\)](#)



### FINDINGS

### PRIMARY TREATMENT



<sup>g</sup>See Principles of Surgery (COL-B 2 of 3).

<sup>ee</sup>Aggressive cytoreductive debulking and/or intraperitoneal chemotherapy are not recommended outside the setting of a clinical trial.

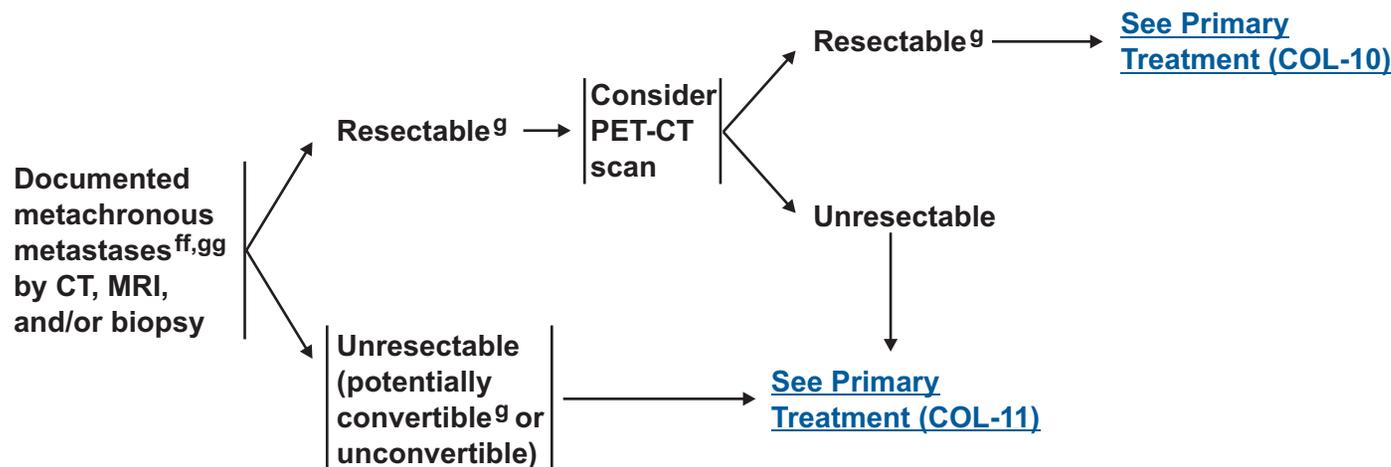
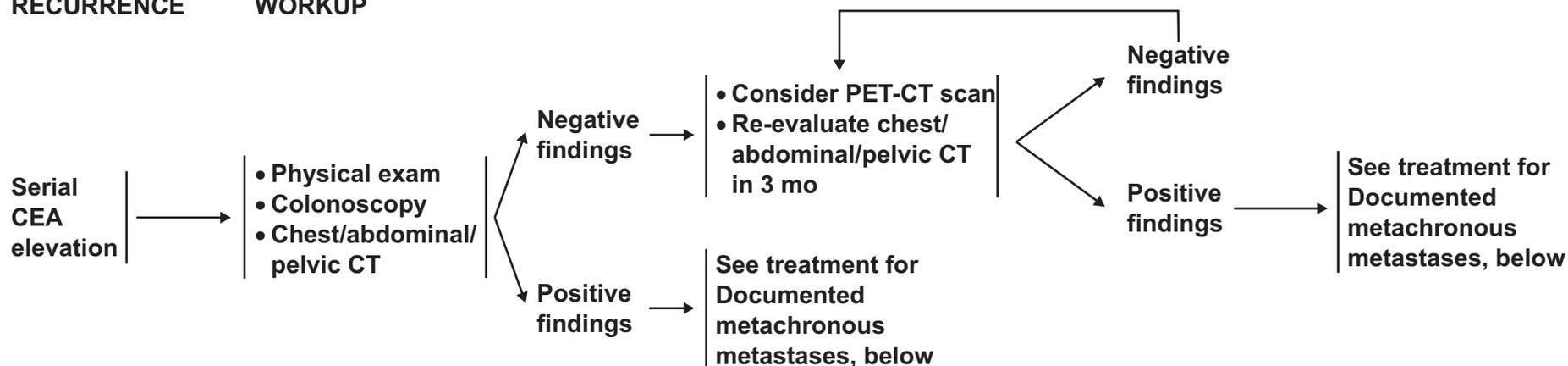
**Note:** All recommendations are category 2A unless otherwise indicated.

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### RECURRENCE

### WORKUP



<sup>g</sup>See Principles of Surgery (COL-B 2 of 3).

<sup>ff</sup>Determination of tumor KRAS (if KRAS non-mutated, consider BRAF testing). See Principles of Pathologic Review (COL-A 4 of 5) - KRAS and BRAF Mutation Testing.

<sup>gg</sup>Patients should be evaluated by a multidisciplinary team including surgical consultation for potentially resectable patients.

**Note:** All recommendations are category 2A unless otherwise indicated.

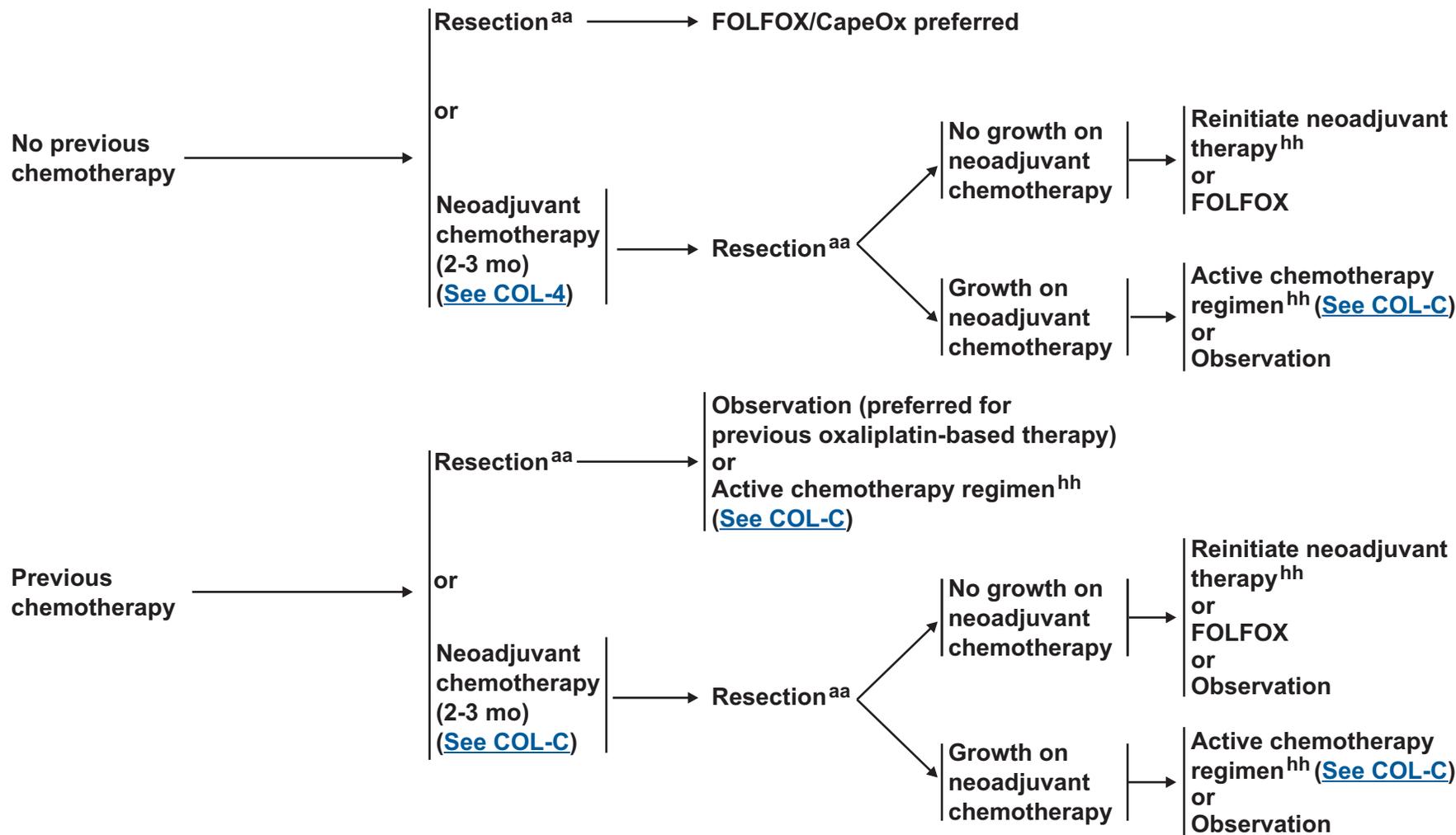
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### RESECTABLE METACHRONOUS METASTASES

### PRIMARY TREATMENT ADJUVANT TREATMENT



<sup>aa</sup>Hepatic artery infusion ± systemic 5-FU/leucovorin (category 2B) is also an option at institutions with experience in both the surgical and medical oncologic aspects of this procedure.

<sup>hh</sup>Perioperative therapy should be considered for up to a total of 6 months.

**Note:** All recommendations are category 2A unless otherwise indicated.

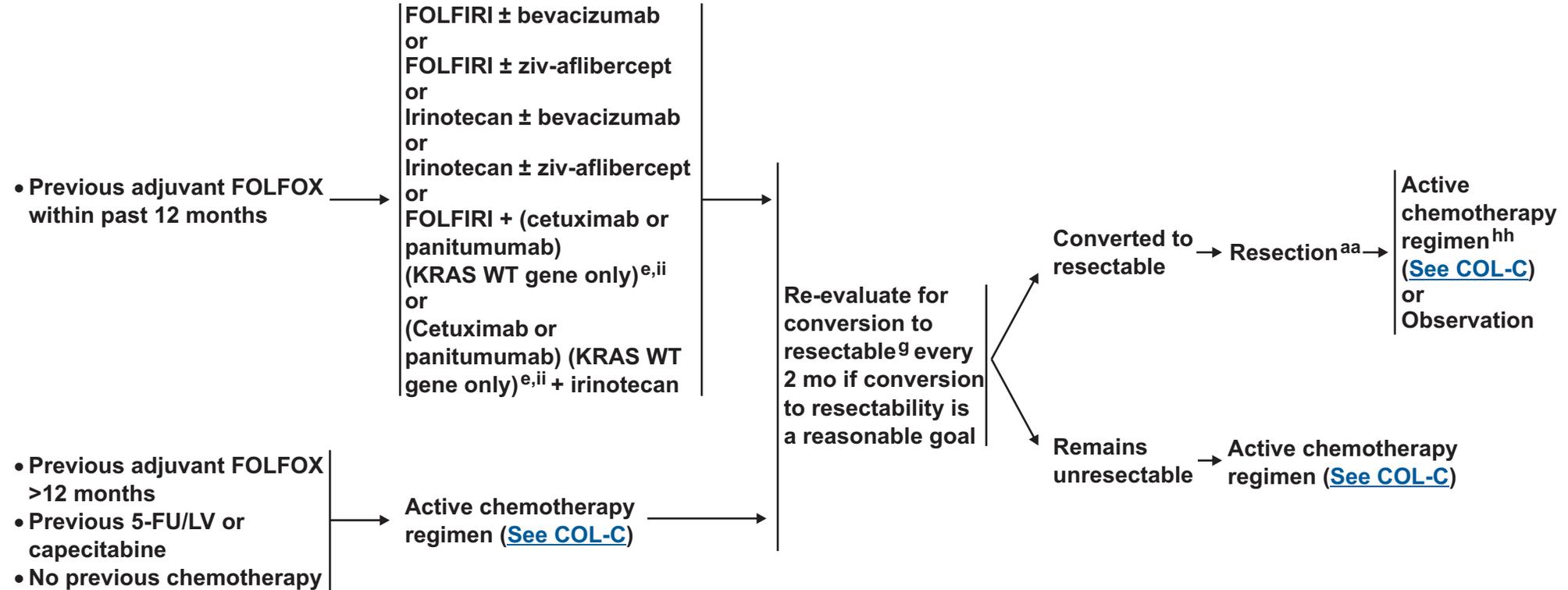
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### UNRESECTABLE METACHRONOUS METASTASES

### PRIMARY TREATMENT



<sup>e</sup>See Principles of Pathologic Review (COL-A 4 of 5) - KRAS and BRAF Mutation Testing.

<sup>g</sup>See Principles of Surgery (COL-B 2 of 3).

<sup>aa</sup>Hepatic artery infusion ± systemic 5-FU/leucovorin (category 2B) is also an option at institutions with experience in both the surgical and medical oncologic aspects of this procedure.

<sup>hh</sup>Perioperative therapy should be considered for up to a total of 6 months.

<sup>ii</sup>Patients with a V600E BRAF mutation appear to have a poorer prognosis. Limited available data suggest a lack of antitumor activity from anti-EGFR monoclonal antibodies in the presence of a V600E mutation when used after a patient has progressed on first-line therapy.

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### PRINCIPLES OF PATHOLOGIC REVIEW (1 of 5)

#### Endoscopically Removed Malignant Polyps

- A malignant polyp is defined as one with cancer invading through the muscularis mucosae and into the submucosa (pT1). pTis is not considered a “malignant polyp.”
- Favorable histologic features: grade 1 or 2, no angiolymphatic invasion, and negative margin of resection. There is no consensus as to the definition of what constitutes a positive margin of resection. A positive margin has been defined as 1) tumor <1 mm from the transected margin, 2) tumor <2 mm from the transected margin, and 3) tumor cells present within the diathermy of the transected margin.<sup>1-4</sup>
- Unfavorable histologic features: grade 3 or 4, angiolymphatic invasion, or a “positive margin.” See the positive margin definition above.
- There is controversy as to whether malignant colorectal polyps with a sessile configuration can be successfully treated by endoscopic removal. The literature seems to indicate that endoscopically removed sessile malignant polyps have a significantly greater incidence of adverse outcomes (residual disease, recurrent disease, mortality, and hematogenous metastasis, but not lymph node metastasis) than do polypoid malignant polyps. However, when one closely looks at the data, configuration by itself is not a significant variable for adverse outcome, and endoscopically removed malignant sessile polyps with grade I or II histology, negative margins, and no lymphovascular invasion can be successfully treated with endoscopic polypectomy.<sup>3-7</sup>

#### Colon Cancer Appropriate for Resection

- Histologic confirmation of primary colonic malignant neoplasm.

#### Pathological Stage

- The following parameters should be reported:
  - Grade of the cancer
  - Depth of penetration, (T)
  - Number of lymph nodes evaluated and number positive (N)
  - Status of proximal, distal, and radial margins<sup>8-9</sup> [See Staging \(ST-1\)](#)
  - Lymphovascular invasion<sup>10,11</sup>
  - Perineural invasion<sup>12-14</sup>
  - Extranodal tumor deposits<sup>15-18</sup>

[See Pathological Stage \(continued\) on COL-A 2 of 5](#)

[See Lymph Node Evaluation on COL-A 3 of 5](#)

[See KRAS and BRAF Mutation Testing on COL-A 4 of 5](#)

[See references on COL-A 5 of 5](#)

Note: All recommendations are category 2A unless otherwise indicated.

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### PRINCIPLES OF PATHOLOGIC REVIEW (2 of 5)

#### Pathological Stage (continued)

- **Radial (circumferential) margin evaluation** - The serosal surface (peritoneal) does not constitute a surgical margin. In colon cancer the circumferential (radial) margin represents the adventitial soft tissue closest to the deepest penetration of tumor, and is created surgically by blunt or sharp dissection of the retroperitoneal aspect. The radial margins should be assessed in all colonic segments with non-peritonealized surfaces. The circumferential resection margin corresponds to any aspect of the colon that is not covered by a serosal layer of mesothelial cells, and must be dissected from the retroperitoneum to remove the viscus. On pathological examination it is difficult to appreciate the demarcation between a peritonealized surface and non-peritonealized surface. Therefore, the surgeon is encouraged to mark the area of non-peritonealized surface with a clip or suture. The mesenteric resection margin is the only relevant circumferential margin in segments completely encased by the peritoneum.<sup>10-11</sup>
- **Perineural invasion (PNI)** - The presence of PNI is associated with a significantly worse prognosis. In multivariate analysis, PNI has been shown to be an independent prognostic factor for cancer-specific and overall disease-free survival. For stage II carcinoma, those with PNI have a significantly worse 5-year disease-free survival compared to those without PNI (29% vs. 82% [p=.0005]).<sup>12-14</sup>
- **Extra nodal tumor deposits** - Irregular discrete tumor deposits in pericolic or perirectal fat away from the leading edge of the tumor and showing no evidence of residual lymph node tissue, but within the lymphatic drainage of the primary carcinoma, are considered peritumoral deposits or satellite nodules and are not counted as lymph nodes replaced by tumor. Most examples are due to lymphovascular or, more rarely, PNI. Because these tumor deposits are associated with reduced disease-free and overall survival, their number should be recorded in the surgical pathology report.  
This poorer outcome has also been noted in patients with stage III carcinoma.<sup>15-18</sup>

[See Endoscopically Removed Malignant Polyps and Colon Cancer Appropriate for Resection on COL-A 1 of 5](#)

[See Lymph Node Evaluation on COL-A 3 of 5](#)

[See KRAS and BRAF Mutation Testing on COL-A 4 of 5](#)

[See references on COL-A 5 of 5](#)

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### PRINCIPLES OF PATHOLOGIC REVIEW (3 of 5)

#### Lymph Node Evaluation

- The AJCC and College of American Pathologists recommend examination of a minimum of 12 lymph nodes to accurately identify stage II colorectal cancers.<sup>8,9,19</sup> The literature lacks consensus as to what is the minimal number of lymph nodes to accurately identify stage II cancer. The minimal number of nodes has been reported as >7, >9, >13, >20, >30.<sup>20-28</sup> The number of lymph nodes retrieved can vary with age of the patient, gender, tumor grade, and tumor site.<sup>21</sup> For stage II (pN0) colon cancer, if fewer than 12 lymph nodes are initially identified, it is recommended that the pathologist go back to the specimen and resubmit more tissue of potential lymph nodes. If 12 lymph nodes are still not identified, a comment in the report should indicate that an extensive search for lymph nodes was undertaken. The pathologist should attempt to retrieve as many lymph nodes as possible. It has been shown that the number of negative lymph nodes is an independent prognostic factor for patients with stage IIIB and IIIC colon cancer.<sup>29</sup>

#### Sentinel Lymph Node and Detection of Micrometastasis by Immunohistochemistry

- Examination of the sentinel lymph node allows an intense histologic and/or immunohistochemical investigation to detect the presence of metastatic carcinoma. Studies in the literature have been reported using multiple hematoxylin and eosin (H & E) sections and/or immunohistochemistry (IHC) to detect cytokeratin-positive cells.<sup>30-34</sup> The significance of detection of single cells by IHC alone is controversial. The 7th edition of the AJCC Cancer Staging Manual and Handbook<sup>35</sup> considers "tumor clusters" <0.2 mm to be isolated tumor cells (pN0) and not metastatic carcinoma. However, some investigators believe that size should not affect the diagnosis of metastatic cancer. They believe that tumor foci that show evidence of growth (eg, glandular differentiation, distension of sinus, stromal reaction) should be diagnosed as a lymph node metastasis regardless of size.<sup>36</sup>
- Some studies have shown that the detection of IHC cytokeratin-positive cells in stage II (N0) colon cancer (defined by H & E) has a worse prognosis, while others have failed to show this survival difference. In these studies, isolated tumor cells were considered to be micrometastases.<sup>37-42</sup>
- At the present time the use of sentinel lymph nodes and detection of cancer cells by IHC alone should be considered investigational, and results should be used with caution in clinical management decisions.<sup>30-34,38-42</sup>

[See Endoscopically Removed Malignant Polyp and Colon Cancer Appropriate for Resection on COL-A 1 of 5](#)

[See Pathological Stage on COL-A 2 of 5](#)

[See KRAS and BRAF Mutation Testing on COL-A 4 of 5](#)

[See references on COL-A 5 of 5](#)

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### PRINCIPLES OF PATHOLOGIC REVIEW (4 of 5)

#### KRAS Mutation Testing

- Mutations in codons 12 and 13 in exon 2 of the coding region of the KRAS gene predict lack of response to therapy with antibodies targeted to the EGFR.<sup>43,44</sup>
- Testing for mutations in codons 12 and 13 should be performed only in laboratories that are certified under the clinical laboratory improvement amendments of 1988 (CLIA-88) as qualified to perform high complexity clinical laboratory (molecular pathology) testing. No specific methodology is recommended (eg, sequencing, hybridization).
- The testing can be performed on formalin-fixed paraffin-embedded tissue. The testing can be performed on the primary colorectal cancers and/or the metastasis, as literature has shown that the KRAS mutations are similar in both specimen types.<sup>45</sup>

#### BRAF Mutation Testing

- Patients with a V600E BRAF mutation appear to have a poorer prognosis. There are insufficient data to guide the use of anti-EGFR therapy in the first-line setting with active chemotherapy based on BRAF V600E mutation status. Limited available data suggest lack of antitumor activity from anti-EGFR monoclonal antibodies in the presence of a V600E mutation when used after a patient has progressed on first-line therapy.<sup>46,47</sup>
- Testing for the BRAF V600E mutation can be performed on formalin-fixed paraffin-embedded tissues. This is usually performed by amplification and direct DNA sequence analysis. Allele-specific PCR is another acceptable method for detecting BRAF V600E mutation. This testing should be performed only in laboratories that are certified under the clinical laboratory improvement amendments of 1988 (CLIA-88) and qualified to perform high complexity clinical laboratory (molecular pathology) testing.

#### MSI Testing - [See NCCN Guidelines for Colorectal Cancer Screening](#)

- The panel recommends that MMR protein testing be performed for all patients younger than 50 years with colon cancer, based on an increased likelihood of Lynch syndrome in this population. MMR testing should also be considered for all patients with stage II disease, because stage II MSI-H patients may have a good prognosis and do not benefit from 5-FU adjuvant therapy.<sup>48</sup>

[See Endoscopically Removed Malignant Polyps and Colon Cancer Appropriate for Resection on COL-A 1 of 5](#)

[See Pathological Stage on COL-A 2 of 5](#)

[See Lymph Node Evaluation on COL-A 3 of 5](#)

[See references on COL-A 5 of 5](#)

Note: All recommendations are category 2A unless otherwise indicated.

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# NCCN Guidelines Version 1.2014

## Colon Cancer

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[Discussion](#)

### PRINCIPLES OF PATHOLOGIC REVIEW - References (5 of 5)

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### PRINCIPLES OF SURGERY (1 of 3)

#### Colectomy

- **Lymphadenectomy**

- ▶ Lymph nodes at the origin of feeding vessel should be identified for pathologic exam.
- ▶ Clinically positive lymph nodes outside the field of resection that are considered suspicious should be biopsied or removed, if possible.
- ▶ Positive nodes left behind indicate an incomplete (R2) resection.
- ▶ A minimum of 12 lymph nodes need to be examined to establish N stage.<sup>1</sup>

- Laparoscopic-assisted colectomy may be considered based upon the following criteria:<sup>2</sup>

- ▶ The surgeon has experience performing laparoscopically assisted colorectal operations.<sup>3,4</sup>
- ▶ There is no locally advanced disease.
- ▶ It is not indicated for acute bowel obstruction or perforation from cancer.
- ▶ Thorough abdominal exploration is required.<sup>5</sup>
- ▶ Consider preoperative marking of small lesions.

- Management of patients with carrier status of known or clinically suspected HNPCC

- ▶ Consider more extensive colectomy for patients with a strong family history of colon cancer or young age (<50 y).

[See NCCN Guidelines for Colorectal Cancer Screening](#)

- Resection needs to be complete to be considered curative.

[See Criteria for Resectability of Metastases and Locoregional Therapies Within Surgery on COL-B 2 of 3](#)

[See footnotes on COL-B 3 of 3](#)

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### PRINCIPLES OF SURGERY (2 of 3)

#### CRITERIA FOR RESECTABILITY OF METASTASES AND LOCOREGIONAL THERAPIES WITHIN SURGERY

##### Liver

- Hepatic resection is the treatment of choice for resectable liver metastases from colorectal cancer.<sup>6</sup>
- Complete resection must be feasible based on anatomic grounds and the extent of disease; maintenance of adequate hepatic function is required.<sup>7</sup>
- The primary tumor must have been resected for cure (R0). There should be no unresectable extrahepatic sites of disease.<sup>8-11</sup> Having a plan for a debulking resection (less than an R0 resection) is not recommended.<sup>7</sup>
- Patients with resectable metastatic disease and a primary tumor in place should have both sites resected with curative intent. These can be resected in one operation or as a staged approach, depending on the complexity of the hepatectomy or colectomy, comorbid diseases, surgical exposure, and surgeon expertise.<sup>12</sup>
- When hepatic metastatic disease is not optimally resectable based on insufficient remnant liver volume, approaches utilizing preoperative portal vein embolization<sup>13</sup> or staged liver resection<sup>14</sup> can be considered.
- Ablative techniques may be considered alone or in conjunction with resection. All original sites of disease need to be amenable to ablation or resection.
- Some institutions use arterially directed embolic therapy (category 3) in highly select patients with chemotherapy-resistant/-refractory disease, without obvious systemic disease, with predominant hepatic metastases.
- Conformal external beam radiation therapy (category 3) may be considered in highly selected cases or in the setting of a clinical trial and should not be used indiscriminately in patients who are potentially surgically resectable.
- Re-resection can be considered in selected patients.<sup>15</sup>

##### Lung

- Complete resection based on the anatomic location and extent of disease with maintenance of adequate function is required.<sup>16-19</sup>
- The primary tumor must have been resected for cure (R0).
- Resectable extrapulmonary metastases do not preclude resection.<sup>20-23</sup>
- Re-resection can be considered in selected patients.<sup>24</sup>
- Ablative techniques can be considered when unresectable and amenable to complete ablation.
- Patients with resectable synchronous metastases can be resected synchronously or using a staged approach.
- Conformal external beam radiation therapy may be considered in highly selected cases or in the setting of a clinical trial and should not be used indiscriminately in patients who are potentially surgically resectable (category 3).

##### Evaluation for Conversion to Resectable Disease

- Re-evaluation for resection should be considered in otherwise unresectable patients after 2 months of preoperative chemotherapy and every 2 months thereafter.<sup>25-28</sup>
- Disease with a higher likelihood of being converted to resectable are those with initially convertible disease distributed within limited sites.
- When considering whether disease has been converted to resectable, all original sites need to be amenable to resection.<sup>29</sup>
- Preoperative chemotherapy regimens with high response rates should be considered for patients with potentially convertible disease.<sup>30</sup>

[See footnotes on COL-B 3 of 3](#)

Note: All recommendations are category 2A unless otherwise indicated.

Clinical Trials: NCCN believes that the best management of any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.



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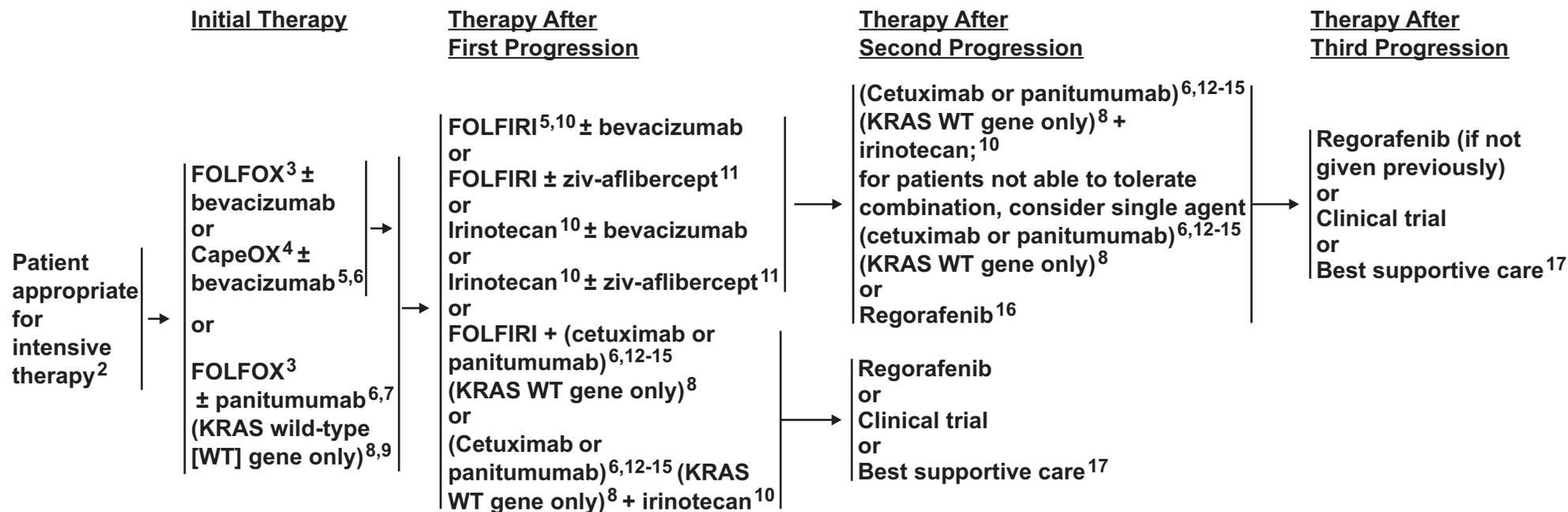
**Note: All recommendations are category 2A unless otherwise indicated.**

**Clinical Trials: NCCN believes that the best management of any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.**





### CONTINUUM OF CARE - CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE:<sup>1</sup> (PAGE 1 of 9)



Additional options on  
[COL-C 2 of 9](#) through [COL-C 3 of 9](#)

For patients not appropriate for  
intensive therapy, see [COL-C 4 of 9](#)

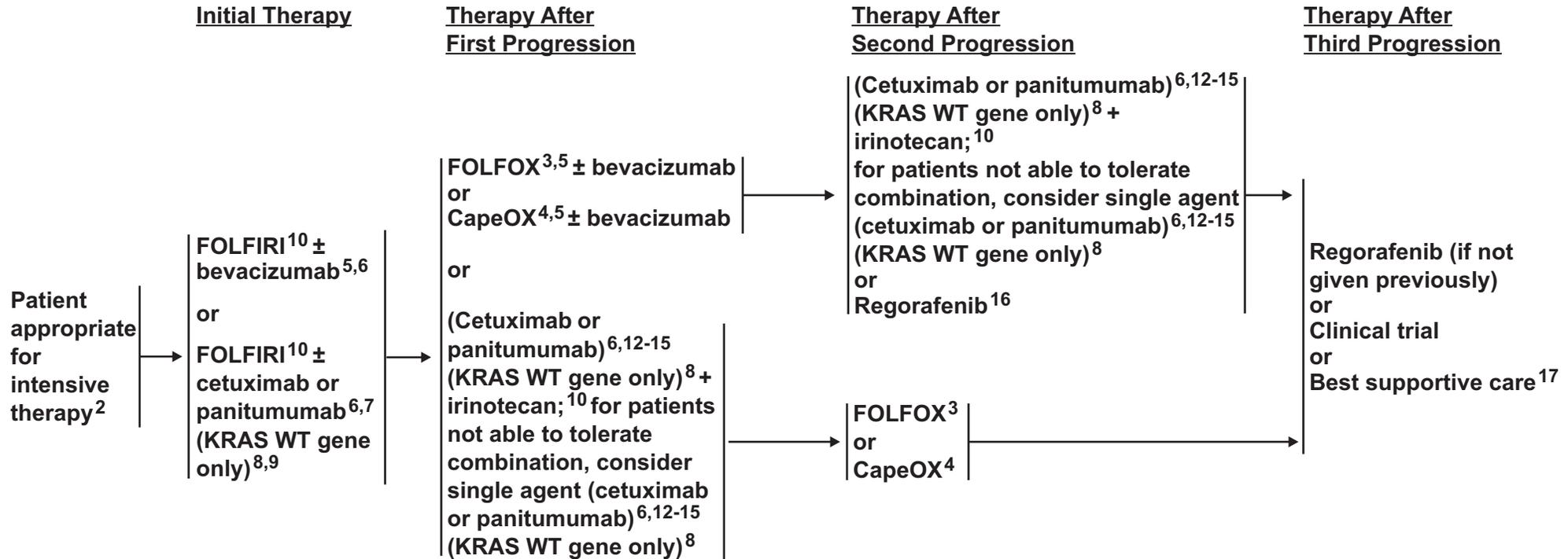
[See footnotes on COL-C 5 of 9](#)

**Note:** All recommendations are category 2A unless otherwise indicated.  
**Clinical Trials:** NCCN believes that the best management of any cancer patient is in a clinical trial. Participation in clinical trials is especially encouraged.





### CONTINUUM OF CARE - CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE:<sup>1</sup> (PAGE 2 of 9)



Additional options on [COL-C 1 of 9](#) through [COL-C 3 of 9](#)

For patients not appropriate for intensive therapy, see [COL-C 4 of 9](#)

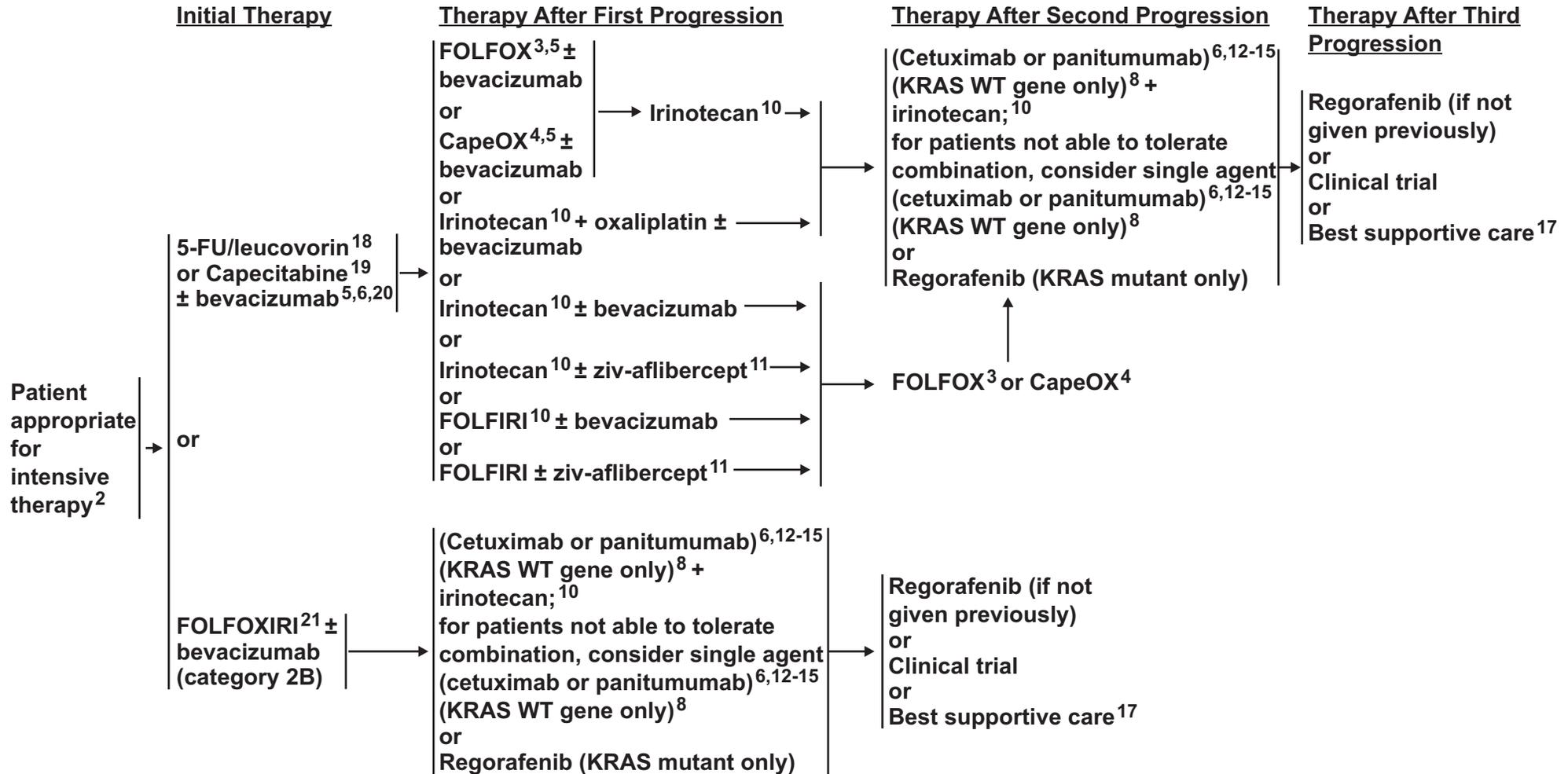
[See footnotes on COL-C 5 of 9](#)

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**CONTINUUM OF CARE - CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE:<sup>1</sup> (PAGE 3 of 9)**



Additional options on [COL-C 1 of 9](#) through [COL-C 2 of 9](#)

For patients not appropriate for intensive therapy, see [COL-C 4 of 9](#)

[See footnotes on COL-C 5 of 9](#)

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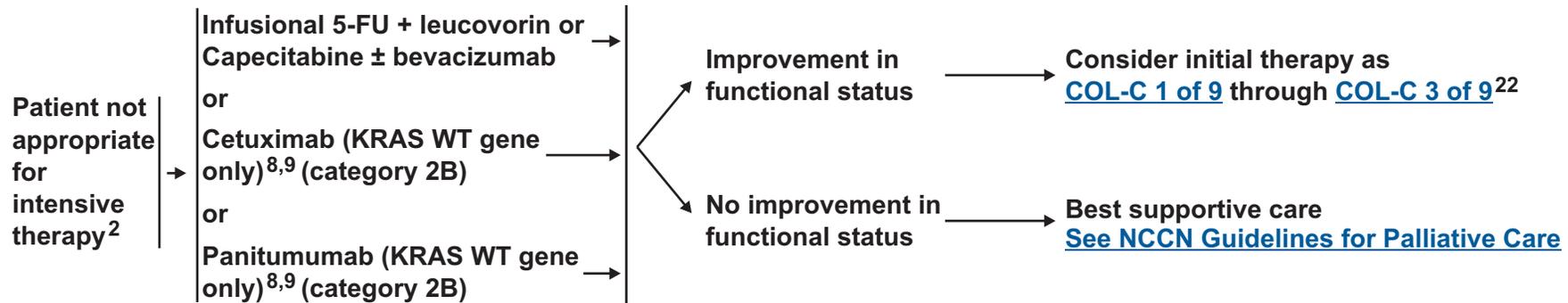




### CONTINUUM OF CARE - CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE:<sup>1</sup> (PAGE 4 of 9)

#### Initial Therapy

#### Therapy After First Progression



[See footnotes on COL-C 5 of 9](#)

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**CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE (PAGE 5 of 9)**

- <sup>1</sup>For chemotherapy references, [see Chemotherapy Regimens and References \(COL-C 6-9\)](#).
- <sup>2</sup>PET-CT should not be used to monitor progress of therapy. CT with contrast or MRI is recommended.
- <sup>3</sup>Discontinuation of oxaliplatin should be strongly considered from FOLFOX or CapeOX after 3-4 months of therapy (or sooner if significant neurotoxicity develops  $\geq$  grade 2) with other drugs maintained (fluoropyrimidine + bevacizumab) until time of tumor progression. Oxaliplatin may be reintroduced if it was discontinued previously for neurotoxicity rather than disease progression. Tournigand C, Cervantes A, Figer A, et al. OPTIMOX1: A randomized study of FOLFOX4 or FOLFOX7 with oxaliplatin in a stop-and-go fashion in advanced colorectal cancer - A GERCOR Study. *J Clin Oncol* 2006;24:394-400. There are no data to support the routine use of Ca/Mg infusion to prevent oxaliplatin-related neurotoxicity and therefore should not be done.
- <sup>4</sup>The majority of safety and efficacy data for this regimen have been developed in Europe, where a capecitabine starting dose of 1000 mg/m<sup>2</sup> twice daily for 14 days, repeated every 21 days, is standard. Evidence suggests that North American patients may experience greater toxicity with capecitabine (as well as with other fluoropyrimidines) than European patients, and may require a lower dose of capecitabine. The relative efficacy of CapeOx with lower starting doses of capecitabine has not been addressed in large-scale randomized trials.
- <sup>5</sup>There is an increased risk of stroke and other arterial events, especially in those aged  $\geq$  65 years. The use of bevacizumab may interfere with wound healing.
- <sup>6</sup>Combination therapy involving cytotoxics, anti-EGFRs, and anti-VEGFs is not recommended. Hecht JR, Mitchell E, Chidiac T, et al. A randomized phase IIIB trial of chemotherapy, bevacizumab, and panitumumab compared with chemotherapy and bevacizumab alone for metastatic colorectal cancer. *J Clin Oncol* 2009;27:672-80. Tol J, Koopman M, Cats A, et al. Chemotherapy, bevacizumab, and cetuximab in metastatic colorectal cancer. *N Engl J Med* 2009;360(6):563-572.
- <sup>7</sup>If cetuximab or panitumumab is used as initial therapy, then neither cetuximab nor panitumumab should be used in second or subsequent lines of therapy.
- <sup>8</sup>[See Principles of Pathologic Review \(COL-A 4 of 5\)](#) - KRAS and BRAF Mutation Testing.
- <sup>9</sup>There are insufficient data to guide the use of anti-EGFR therapy in the first-line setting with active chemotherapy based on BRAF V600E mutation status.
- <sup>10</sup>Irinotecan should be used with caution and with decreased doses in patients with Gilbert's disease or elevated serum bilirubin. There is a commercially available test for UGT1A1. Guidelines for use in clinical practice have not been established.
- <sup>11</sup>There are no data to suggest activity of FOLFIRI-ziv-aflibercept in a patient who has progressed on FOLFIRI-bevacizumab, or vice versa. Ziv-aflibercept has only shown activity when given in conjunction with FOLFIRI in FOLFIRI-naïve patients.
- <sup>12</sup>Cetuximab is indicated in combination with irinotecan-based therapy or as single-agent therapy for patients who cannot tolerate irinotecan.
- <sup>13</sup>EGFR testing has no demonstrated predictive value; therefore, routine EGFR testing is not recommended. No patient should be included or excluded from cetuximab or panitumumab therapy on the basis of EGFR test results.
- <sup>14</sup>There are no data, nor is there a compelling rationale, to support the use of panitumumab after clinical failure on cetuximab, or the use of cetuximab after clinical failure on panitumumab. As such, the use of one of these agents after therapeutic failure on the other is not recommended.
- <sup>15</sup>Patients with a V600E BRAF mutation appear to have a poorer prognosis. Limited available data suggest lack of antitumor activity from anti-EGFR monoclonal antibodies in the presence of a V600E mutation when used after a patient has progressed on first-line therapy.
- <sup>16</sup>Regorafenib is a treatment option for patients who have progressed through all available regimens (e.g. KRAS mutant or KRAS WT with previous exposure to anti-EGFR inhibitor.)
- <sup>17</sup>Single-agent or combination therapy with capecitabine, mitomycin, or gemcitabine has not been shown to be effective in this setting.
- <sup>18</sup>Infusional 5-FU is preferred.
- <sup>19</sup>Patients with diminished creatinine clearance may require dose modification of capecitabine.
- <sup>20</sup>A treatment option for patients not able to tolerate oxaliplatin or irinotecan.
- <sup>21</sup>Data are not mature for the addition of biologic agents to FOLFOXIRI.
- <sup>22</sup>The use of single-agent capecitabine as a salvage therapy after failure on a fluoropyrimidine-containing regimen has been shown to be ineffective; therefore, this is not recommended.

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### CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE - CHEMOTHERAPY REGIMENS (PAGE 6 of 9)

#### FOLFOX

##### mFOLFOX 6

Oxaliplatin 85 mg/m<sup>2</sup> IV over 2 hours, day 1  
Leucovorin\* 400 mg/m<sup>2</sup> IV over 2 hours, day 1  
5-FU 400 mg/m<sup>2</sup> IV bolus on day 1, then 1200 mg/m<sup>2</sup>/day x 2 days  
(total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
Repeat every 2 weeks<sup>1,2,3</sup>

##### mFOLFOX6 + Bevacizumab<sup>2,4,¶</sup>

Oxaliplatin 85 mg/m<sup>2</sup> IV over 2 hours, day 1  
Leucovorin\* 400 mg/m<sup>2</sup> IV over 2 hours, day 1  
5-FU 400 mg/m<sup>2</sup> IV bolus on day 1, then 1200 mg/m<sup>2</sup>/day x 2 days  
(total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
Bevacizumab 5 mg/kg IV, day 1  
Repeat every 2 weeks

##### mFOLFOX6 + Panitumumab<sup>2,5</sup>

Oxaliplatin 85 mg/m<sup>2</sup> IV over 2 hours, day 1  
Leucovorin\* 400 mg/m<sup>2</sup> IV over 2 hours, day 1  
5-FU 400 mg/m<sup>2</sup> IV bolus on day 1, then 1200 mg/m<sup>2</sup>/day x 2 days  
(total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
Panitumumab 6 mg/kg IV over 60 minutes, day 1  
Repeat every 2 weeks

#### CapeOX<sup>1,6</sup>

Oxaliplatin 130 mg/m<sup>2</sup> IV over 2 hours, day 1  
Capecitabine 850-1000‡ mg/m<sup>2</sup> twice daily PO for 14 days  
Repeat every 3 weeks

#### CapeOX + Bevacizumab<sup>1,6,7¶</sup>

Oxaliplatin 130 mg/m<sup>2</sup> IV over 2 hours, day 1  
Capecitabine 850-1000‡ mg/m<sup>2</sup> PO twice daily for 14 days  
Bevacizumab 7.5 mg/kg IV, day 1  
Repeat every 3 weeks

**IMPORTANT NOTE REGARDING LEUCOVORIN SHORTAGE, PLEASE SEE [MS-13](#)**

[See References on COL-C 9 of 9](#)

\*Leucovorin 400 mg/m<sup>2</sup> is the equivalent of levoleucovorin 200 mg/m<sup>2</sup>.

†NCCN recommends limiting chemotherapy orders to 24-h units (ie, 1200 mg/m<sup>2</sup>/day NOT 2400 mg/m<sup>2</sup> over 48 hours) to minimize medication errors.

‡The majority of safety and efficacy data for this regimen have been developed in Europe, where a capecitabine starting dose of 1000 mg/m<sup>2</sup> twice daily for 14 days, repeated every 21 days, is standard. Evidence suggests that North American patients may experience greater toxicity with capecitabine (as well as with other fluoropyrimidines) than European patients, and may require a lower dose of capecitabine. The relative efficacy of CapeOx with lower starting doses of capecitabine has not been addressed in large-scale randomized trials.

¶Bevacizumab may be safely given at a rate of 0.5 mg/kg/minute (5 mg/kg over 10 minutes and 7.5 mg/kg over 15 minutes).

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**CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE - CHEMOTHERAPY REGIMENS (PAGE 7 of 9)****FOLFIRI<sup>8</sup>**

Irinotecan 180 mg/m<sup>2</sup> IV over 30-90 minutes, day 1  
 Leucovorin\* 400 mg/m<sup>2</sup> IV infusion to match duration of irinotecan infusion, day 1  
 5-FU 400 mg/m<sup>2</sup> IV bolus day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)† continuous infusion  
 Repeat every 2 weeks

**FOLFIRI<sup>8</sup> + Bevacizumab<sup>9,¶</sup>**

Irinotecan 180 mg/m<sup>2</sup> IV over 30-90 minutes, day 1  
 Leucovorin\* 400 mg/m<sup>2</sup> IV infusion to match duration of irinotecan infusion, day 1  
 5-FU 400 mg/m<sup>2</sup> IV bolus day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
 Bevacizumab 5 mg/kg IV, day 1  
 Repeat every 2 weeks

**FOLFIRI<sup>8</sup> + Cetuximab**

Irinotecan 180 mg/m<sup>2</sup> IV over 30-90 minutes, day 1  
 Leucovorin\* 400 mg/m<sup>2</sup> IV infusion to match duration of irinotecan infusion, day 1  
 5-FU 400 mg/m<sup>2</sup> IV bolus day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
 Repeat every 2 weeks  
 Cetuximab 400 mg/m<sup>2</sup> IV over 2 hours first infusion, then 250 mg/m<sup>2</sup> IV over 60 minutes weekly<sup>10</sup>  
 or Cetuximab 500 mg/m<sup>2</sup> IV over 2 hours, day 1, every 2 weeks<sup>11</sup>

**FOLFIRI<sup>7</sup> + Panitumumab<sup>12</sup>**

Irinotecan 180 mg/m<sup>2</sup> IV over 30-90 minutes, day 1  
 Leucovorin\* 400 mg/m<sup>2</sup> IV infusion to match duration of irinotecan infusion, day 1  
 5-FU 400 mg/m<sup>2</sup> IV bolus day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)† IV continuous infusion  
 Panitumumab 6 mg/kg IV over 60 minutes, day 1  
 Repeat every 2 weeks

**FOLFIRI + ziv-aflibercept<sup>13</sup>**

Irinotecan 180 mg/m<sup>2</sup> IV over 30-90 minutes, day 1  
 Leucovorin\* 400 mg/m<sup>2</sup> IV infusion to match duration of irinotecan infusion, day 1  
 5-FU 400 mg/m<sup>2</sup> IV bolus day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)† continuous infusion  
 Ziv-aflibercept 4 mg/kg IV  
 Repeat every 2 weeks

**Capecitabine<sup>14</sup>**

850-1250 mg/m<sup>2</sup> PO twice daily, days 1-14  
 Repeat every 3 weeks

**Capecitabine<sup>14</sup> + Bevacizumab<sup>7¶</sup>**

Capecitabine 850-1250 mg/m<sup>2</sup> PO twice daily, days 1-14  
 Bevacizumab 7.5 mg/kg IV, day 1  
 Repeat every 3 weeks

**IMPORTANT NOTE REGARDING LEUCOVORIN SHORTAGE, PLEASE SEE [MS-13](#)**

[See References on COL-C 9 of 9](#)

\*Leucovorin 400 mg/m<sup>2</sup> is the equivalent of levoleucovorin 200 mg/m<sup>2</sup>.

†NCCN recommends limiting chemotherapy orders to 24-h units (ie, 1200 mg/m<sup>2</sup>/day NOT 2400 mg/m<sup>2</sup> over 48 hours) to minimize medication errors.

¶Bevacizumab may be safely given at a rate of 0.5 mg/kg/minute (5 mg/kg over 10 minutes and 7.5 mg/kg over 15 minutes).

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**CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE - CHEMOTHERAPY REGIMENS (PAGE 8 of 9)**

**Bolus or infusional 5-FU/leucovorin**

**Roswell Park regimen<sup>15</sup>**

Leucovorin 500 mg/m<sup>2</sup> IV over 2 hours, days 1, 8, 15, 22, 29, and 36

5-FU 500 mg/m<sup>2</sup> IV bolus 1 hour after start of leucovorin,  
days 1, 8, 15, 22, 29, and 36

Repeat every 8 weeks

**Simplified biweekly infusional 5-FU/LV (sLV5FU2)<sup>8</sup>**

Leucovorin\* 400 mg/m<sup>2</sup> IV over 2 hours on day 1,  
followed by 5-FU bolus 400 mg/m<sup>2</sup> and then 1200 mg/m<sup>2</sup>/day x 2 days  
(total 2400 mg/m<sup>2</sup> over 46-48 hours)<sup>†</sup> continuous infusion

Repeat every 2 weeks

**Weekly**

Leucovorin 20 mg/m<sup>2</sup> IV over 2 hours on day 1, 5-FU 500 mg/m<sup>2</sup> IV  
bolus injection 1 hour after the start of leucovorin. Repeat weekly.<sup>16</sup>

5-FU 2600 mg/m<sup>2</sup> by 24-hour infusion plus leucovorin 500 mg/m<sup>2</sup>  
Repeat every week<sup>17</sup>

**IROX<sup>18</sup>**

Oxaliplatin 85 mg/m<sup>2</sup> IV over 2 hours, followed by irinotecan 200  
mg/m<sup>2</sup> over 30 or 90 minutes every 3 weeks

**FOLFOXIRI<sup>19</sup>**

Irinotecan 165 mg/m<sup>2</sup> IV day 1, oxaliplatin 85 mg/m<sup>2</sup> day 1, leucovorin  
400\* mg/m<sup>2</sup> day 1, fluorouracil 1600 mg/m<sup>2</sup>/day x 2 days (total 3200  
mg/m<sup>2</sup> over 48 hours)<sup>†</sup> continuous infusion starting on day 1.

Repeat every 2 weeks

± Bevacizumab<sup>20</sup> 5 mg/kg IV, day 1

**Irinotecan**

Irinotecan 125 mg/m<sup>2</sup> IV over 30-90 minutes, days 1 and 8

Repeat every 3 weeks<sup>21,22</sup>

Irinotecan 300-350 mg/m<sup>2</sup> IV over 30-90 minutes, day 1

Repeat every 3 weeks

Cetuximab (KRAS WT gene only) ± irinotecan<sup>11,23</sup>

Cetuximab 400 mg/m<sup>2</sup> first infusion, then 250 mg/m<sup>2</sup> IV weekly  
or Cetuximab 500 mg/m<sup>2</sup> IV every 2 weeks<sup>11</sup>

±

Irinotecan 300-350 mg/m<sup>2</sup> IV every 3 weeks

or Irinotecan 180 mg/m<sup>2</sup> IV every 2 weeks

or Irinotecan 125 mg/m<sup>2</sup> on days 1 and 8 and repeat every 3 weeks

**Cetuximab (KRAS WT gene only)**

Cetuximab 400 mg/m<sup>2</sup> first infusion, then 250 mg/m<sup>2</sup> IV weekly<sup>23</sup>

or Cetuximab 500 mg/m<sup>2</sup> IV over 2 hours, day 1, every 2 weeks<sup>11</sup>

**Panitumumab<sup>24</sup> (KRAS WT gene only)**

Panitumumab 6 mg/kg IV over 60 minutes every 2 weeks

**Regorafenib<sup>25</sup>**

Regorafenib 160 mg PO daily days 1-21

Repeat every 28 days

**IMPORTANT NOTE REGARDING LEUCOVORIN  
SHORTAGE, PLEASE SEE [MS-13](#)**

[See References on COL-C 9 of 9](#)

\*Leucovorin 400 mg/m<sup>2</sup> is the equivalent of levoleucovorin 200 mg/m<sup>2</sup>.

<sup>†</sup>NCCN recommends limiting chemotherapy orders to 24-h units (ie, 1200 mg/m<sup>2</sup>/day NOT 2400 mg/m<sup>2</sup> over 48 hours) to minimize medication errors.

<sup>¶¶</sup>Bevacizumab may be safely given at a rate of 0.5 mg/kg/minute (5 mg/kg over 10 minutes and 7.5 mg/kg over 15 minutes).

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## CHEMOTHERAPY FOR ADVANCED OR METASTATIC DISEASE - REFERENCES (PAGE 9 of 9)

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### PRINCIPLES OF RISK ASSESSMENT FOR STAGE II DISEASE<sup>1,2,3</sup>

- **Patient/physician discussion regarding the potential risks of therapy compared to potential benefits, including prognosis. This should include discussion of evidence supporting treatment, assumptions of benefit from indirect evidence, morbidity associated with treatment, high-risk characteristics, and patient preferences.**
- **When determining if adjuvant therapy should be administered, the following should be taken into consideration:**
  - **Number of lymph nodes analyzed after surgery (<12)**
  - **Poor prognostic features (eg, poorly differentiated histology [exclusive of those that are MSI-H]; lymphatic/vascular invasion; bowel obstruction; perineural invasion; localized perforation; close, indeterminate, or positive margins)**
  - **Assessment of other comorbidities and anticipated life expectancy.**
- **The benefit of adjuvant chemotherapy does not improve survival by more than 5%.**
- **MSI Testing - [See NCCN Guidelines for Colorectal Cancer Screening](#)**

The panel recommends that MMR protein testing be performed for all patients younger than 50 years with colon cancer, based on an increased likelihood of Lynch syndrome in this population. MMR testing should also be considered for all patients with stage II disease, because stage II MSI-H patients may have a good prognosis and do not benefit from 5-FU adjuvant therapy.<sup>4</sup>

<sup>1</sup>Benson III AB, Schrag D, Somerfield MR, et al. American Society of Clinical Oncology recommendations on adjuvant chemotherapy for stage II colon cancer. J Clin Oncol 2004;16:3408-3419.

<sup>2</sup>Figueredo A, Charette ML, Maroun J, et al. Adjuvant therapy for stage II colon cancer: a systematic review from the cancer care ontario program in evidence-based care's gastrointestinal cancer disease site group. J Clin Oncol 2004;16:3395-3407.

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See [NCCN Guidelines for Colorectal Cancer Screening](#).

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### PRINCIPLES OF ADJUVANT THERAPY (1 OF 2)

- **Capecitabine appears to be equivalent to bolus 5-FU/leucovorin in patients with stage III colon cancer.**<sup>1</sup>
- **FOLFOX is superior to fluoropyrimidine therapy alone for patients with stage III colon cancer.**<sup>2,3</sup> FOLFOX is reasonable for high-risk or intermediate-risk stage II patients and is not indicated for good- or average-risk patients with stage II colon cancer. FLOX is an alternative to FOLFOX.<sup>4</sup>
- **A survival benefit has not been demonstrated for the addition of oxaliplatin to 5-FU/leucovorin in stage II colon cancer.**<sup>5</sup>
- **A benefit for the addition of oxaliplatin to 5-FU/leucovorin in patients age 70 and older has not been proven.**<sup>5</sup>
- **Bolus 5-FU/leucovorin/irinotecan should not be used in adjuvant therapy,**<sup>6</sup> and infusional 5-FU/leucovorin/irinotecan (FOLFIRI) has not been shown to be superior to 5-FU/LV.<sup>7,8</sup> Capecitabine/oxaliplatin is superior to bolus 5-FU/leucovorin.<sup>9</sup>
- **Bevacizumab, cetuximab, panitumumab, or irinotecan should not be used in the adjuvant setting for patients with stage II or III colon cancer outside the setting of a clinical trial.**

[See Principles of Adjuvant Therapy - Chemotherapy Regimens and References on COL-E 2 of 2](#)

<sup>1</sup>Twelves C, Wong A, Nowacki MP, et al. Capecitabine as adjuvant treatment for stage III colon cancer. *N Engl J Med* 2005;352(26):2696-704.

<sup>2</sup>Andre T, Boni C, Mounedji-Boudiaf L, et al. Oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment for colon cancer. *N Engl J Med* 2004;350:2343-51.

<sup>3</sup>Andre T, Boni C, Navarro M, et al. Improved overall survival with oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment in stage II or III colon cancer in the MOSAIC trial. *J Clin Oncol* 2009;27:3109-16. Epub 2009 May 18.

<sup>4</sup>Kuebler JP, Wieand HS, O'Connell MJ, et al. Oxaliplatin combined with weekly bolus fluorouracil and leucovorin as surgical adjuvant chemotherapy for stage II and III colon cancer: results from NSABP C-07. *J Clin Oncol* 2007;25:2198-2204.

<sup>5</sup>Tournigand C, André T, Bonnetain F, et al. Adjuvant therapy with fluorouracil and oxaliplatin in stage II and elderly (between ages 70 and 75 years) with colon cancer: a subgroup analyses of the Multicenter International Study of oxaliplatin, fluorouracil, and leucovorin in the adjuvant treatment of colon cancer trial. *J Clin Oncol* 2012;published online ahead of print on August 20, 2012.

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<sup>9</sup>Haller DG, Tabernero J, Maroun J, et al. Capecitabine plus oxaliplatin compared with fluorouracil and folinic acid as adjuvant therapy for stage III colon cancer. *J Clin Oncol* 2011;29:1465-1471.

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### PRINCIPLES OF ADJUVANT THERAPY - CHEMOTHERAPY REGIMENS AND REFERENCES (2 of 2)

#### mFOLFOX 6

Oxaliplatin 85 mg/m<sup>2</sup> IV over 2 hours, day 1. Leucovorin\* 400 mg/m<sup>2</sup> IV over 2 hours, day 1. 5-FU 400 mg/m<sup>2</sup> IV bolus on day 1, then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)<sup>†</sup> continuous infusion. Repeat every 2 weeks.<sup>1,2,3</sup>

#### FLOX<sup>4</sup>

5-FU 500 mg/m<sup>2</sup> IV bolus weekly x 6 + leucovorin 500 mg/m<sup>2</sup> IV weekly x 6, each 8-week cycle x 3 with oxaliplatin 85 mg/m<sup>2</sup> IV administered on weeks 1, 3, and 5 of each 8-week cycle x 3.

#### Capecitabine<sup>5</sup>

Capecitabine 1250 mg/m<sup>2</sup> twice daily days 1-14 every 3 wks x 24 wks.

#### CapeOx<sup>6</sup>

Oxaliplatin 130 mg/m<sup>2</sup> over 2 hours, day 1. Capecitabine 1000 mg/m<sup>2</sup> twice daily days 1-14 every 3 weeks x 24 weeks.

#### 5-FU/leucovorin

- Leucovorin 500 mg/m<sup>2</sup> given as a 2-hour infusion and repeated weekly x 6. 5-FU 500 mg/m<sup>2</sup> given bolus 1 hour after the start of leucovorin and repeated 6 x weekly. Every 8 weeks for 4 cycles.<sup>7</sup>
- Simplified biweekly infusional 5-FU/LV (sLV5FU2)<sup>8</sup>  
Leucovorin 400\* mg/m<sup>2</sup> IV over 2 hours on day 1, followed by 5-FU bolus 400 mg/m<sup>2</sup> and then 1200 mg/m<sup>2</sup>/day x 2 days (total 2400 mg/m<sup>2</sup> over 46-48 hours)<sup>†</sup> continuous infusion. Repeat every 2 weeks

\*Leucovorin 400 mg/m<sup>2</sup> is the equivalent of levoleucovorin 200 mg/m<sup>2</sup>.

<sup>†</sup>NCCN recommends limiting chemotherapy orders to 24-h units (ie, 1200 mg/m<sup>2</sup>/day NOT 2400 mg/m<sup>2</sup> over 48 hours) to minimize medication errors.

**IMPORTANT NOTE REGARDING LEUCOVORIN SHORTAGE, PLEASE SEE [MS-13](#)**

<sup>1</sup>Andre T, Boni C, Mounedji-Boudiaf L, et al. Oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment for colon cancer. *N Engl J Med* 2004;350:2343-2351.

<sup>2</sup>Cheeseman SL, Joel SP, Chester JD, et al. A 'modified de Gramont' regimen of fluorouracil, alone and with oxaliplatin, for advanced colorectal cancer. *Br J Cancer* 2002;87:393-399. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/12177775>.

<sup>3</sup>Maindault-Goebel F, deGramont A, Louvet C, et al. Evaluation of oxaliplatin dose intensity in bimonthly leucovorin and 48-hour 5-fluorouracil continuous infusion regimens (FOLFOX) in pretreated metastatic colorectal cancer. *Annals of Oncology* 2000;11:1477-1483.

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<sup>7</sup>Haller DG, Catalano PJ, Macdonald JS, Mayer RJ. Phase III study of fluorouracil, leucovorin and levamisole in high risk stage II and III colon cancer: final report of Intergroup 0089. *J Clin Oncol* 2005;23:8671-8678.

<sup>8</sup>Andre T, Louvet C, Maindault-Goebel F, et al. CPT-11 (irinotecan) addition to bimonthly, high-dose leucovorin and bolus and continuous-infusion 5-fluorouracil (FOLFIRI) for pretreated metastatic colorectal cancer. *Eur J Cancer* 1999;35(9):1343-7.

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### PRINCIPLES OF RADIATION THERAPY

- Radiation therapy fields should include the tumor bed, which should be defined by preoperative radiological imaging and/or surgical clips.
- Radiation doses should be: 45-50 Gy in 25-28 fractions.
  - Consider boost for close or positive margins.
  - Small bowel dose should be limited to 45 Gy.
  - 5-FU-based chemotherapy should be delivered concurrently with radiation.
- If radiation therapy is to be used, conformal external beam radiation should be routinely used and intensity-modulated radiation therapy (IMRT) should be reserved only for unique clinical situations including re-irradiation of previously treated patients with recurrent disease.
- Intraoperative radiation therapy (IORT), if available, should be considered for patients with T4 or recurrent cancers as an additional boost. Preoperative radiation therapy with concurrent 5-FU-based chemotherapy is a consideration for these patients to aid resectability. If IORT is not available, additional 10-20 Gy external beam radiation and/or brachytherapy could be considered to a limited volume.
- Some institutions use arterially directed embolization using Yttrium-90 microspheres in select patients with chemotherapy-resistant/refractory disease, without obvious systemic disease, and with predominant hepatic metastases (category 3).
- In patients with a limited number of liver or lung metastases, radiotherapy can be considered in highly selected cases or in the setting of a clinical trial. Radiotherapy should not be used in the place of surgical resection. Radiotherapy should be delivered in a highly conformal manner. The techniques can include 3-D conformal radiation therapy, IMRT, or stereotactic body radiation therapy (SBRT) (category 3).

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### PRINCIPLES OF SURVIVORSHIP - Colorectal Long-term Follow-up Care

#### Colorectal Cancer Surveillance:

- See [COL-3](#) and [COL-4](#)
- Long-term surveillance should be carefully managed with routine good medical care and monitoring, including cancer screening, routine health care, and preventive care.
- Routine CEA monitoring and routine CT scanning are not recommended beyond 5 years.

#### Management of Late Sequelae of Disease or Treatment:<sup>1-5</sup>

- For chronic diarrhea or incontinence
  - Consider anti-diarrheal agents, bulk-forming agents, diet manipulation, and protective undergarments.

#### Prescription for Survivorship and Transfer of Care to Primary Care

Physician<sup>6</sup> (If primary physician will be assuming cancer surveillance responsibilities):

- Include overall summary of treatment, including all surgeries, radiation treatments, and chemotherapy received.
- Describe possible clinical course, including expected time to resolution of acute toxicities, long-term effects of treatment, and possible late sequelae of treatment.
- Include surveillance recommendations.
- Delineate appropriate timing of transfer of care with specific responsibilities identified for primary care physician and oncologist.

#### Cancer Screening Recommendations:

These recommendations are for average-risk patients.

Recommendations for high-risk individuals should be made on an individual basis.

- Breast Cancer: See the [NCCN Guidelines for Breast Cancer Screening](#)
- Prostate Cancer: See the [NCCN Guidelines for Prostate Early Detection](#)

#### Counseling Regarding Healthy Lifestyle and Wellness:<sup>7</sup>

- Maintain a healthy body weight throughout life.
- Adopt a physically active lifestyle (At least 30 minutes of moderate intensity activity on most days of the week). Activity recommendations may require modification based on treatment sequelae (ie, ostomy, neuropathy).
- Consume a healthy diet with emphasis on plant sources.
- Limit alcohol consumption.
- Receive smoking cessation counseling as appropriate.

Additional health monitoring and immunizations should be performed as indicated under the care of a primary care physician. Survivors are encouraged to maintain a therapeutic relationship with a primary care physician throughout their lifetime.

<sup>1</sup>Schneider EC, Malin JL, Kahn KL, et al. Surviving colorectal cancer. *Cancer* 2007;110:2075-82.

<sup>2</sup>Sprangers MAG, Taal BG, Aaronson NK, et al. Quality of life in colorectal cancer: stoma vs. nonstoma patients. *Dis Colon Rectum* 1995;38:361-9.

<sup>3</sup>Gami B, Harrington K, Blake P, et al. How patients manage gastrointestinal symptoms after pelvic radiotherapy. *Aliment Pharmacol Ther* 2003;18:987-94.

<sup>4</sup>DeSnoo L, Faithfull S. A qualitative study of anterior resection syndrome: the experiences of cancer survivors who have undergone resection surgery. *Eur J Cancer* 2006;15:244-51.

<sup>5</sup>McGough C, Baldwin C, Frost C, Andreyev HJN. Role of nutritional intervention in patients treated with radiotherapy for pelvic malignancy. *Br J Cancer* 2004;90:2278-87.

<sup>6</sup>Hewitt M, Greenfield S, Stovall E. *From Cancer Patient to Cancer Survivor: Lost in Transition*. Washington, D.C.:The National Academies Press;2006.

<sup>7</sup>Kushi LH, Byers T, Doyle C, et al and The American Cancer Society 2006 Nutrition and Physical Activity Guidelines Advisory Committee. American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention: Reducing the Risk of Cancer With Healthy Food Choices and Physical Activity *CA Cancer J Clin* 2006;56:254-281.

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**Table 1. Definitions for T, N, M**

**Primary Tumor (T)**

TX	Primary tumor cannot be assessed
T0	No evidence of primary tumor
Tis	Carcinoma in situ: intraepithelial or invasion of lamina propria <sup>a</sup>
T1	Tumor invades submucosa
T2	Tumor invades muscularis propria
T3	Tumor invades through the muscularis propria into the pericolorectal tissues
T4a	Tumor penetrates to the surface of the visceral peritoneum <sup>b</sup>
T4b	Tumor directly invades or is adherent to other organs or structures <sup>b,c</sup>

**Regional Lymph Nodes (N)**

NX	Regional lymph nodes cannot be assessed
N0	No regional lymph node metastasis
N1	Metastasis in 1-3 regional lymph nodes
N1a	Metastasis in one regional lymph node
N1b	Metastasis in 2-3 regional lymph nodes
N1c	Tumor deposit(s) in the subserosa, mesentery, or nonperitonealized pericolic or perirectal tissues without regional nodal metastasis
N2	Metastasis in four or more regional lymph nodes
N2a	Metastasis in 4-6 regional lymph nodes
N2b	Metastasis in seven or more regional lymph nodes

**Distant Metastasis (M)**

M0	No distant metastasis
M1	Distant metastasis
M1a	Metastasis confined to one organ or site (eg, liver, lung, ovary, nonregional node)
M1b	Metastases in more than one organ/site or the peritoneum

<sup>a</sup>Tis includes cancer cells confined within the glandular basement membrane (intraepithelial) or mucosal lamina propria (intramucosal) with no extension through the muscularis mucosae into the submucosa.

<sup>b</sup>Direct invasion in T4 includes invasion of other organs or other segments of the colorectum as a result of direct extension through the serosa, as confirmed on microscopic examination (for example, invasion of the sigmoid colon by a carcinoma of the cecum) or, for cancers in a retroperitoneal or subperitoneal location, direct invasion of other organs or structures by virtue of extension beyond the muscularis propria (i.e., respectively, a tumor on the posterior wall of the descending colon invading the left kidney or lateral abdominal wall; or a mid or distal rectal cancer with invasion of prostate, seminal vesicles, cervix, or vagina).

<sup>c</sup>Tumor that is adherent to other organs or structures, grossly, is classified cT4b. However, if no tumor is present in the adhesion, microscopically, the classification should be pT1-4a depending on the anatomical depth of wall invasion. The V and L classifications should be used to identify the presence or absence of vascular or lymphatic invasion whereas the PN site-specific factor should be used for perineural invasion.

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**Table 2. Anatomic Stage/Prognostic Groups**

Stage	T	N	M	Dukes*	MAC*
0	Tis	N0	M0	-	-
I	T1	N0	M0	A	A
	T2	N0	M0	A	B1
IIA	T3	N0	M0	B	B2
IIB	T4a	N0	M0	B	B2
IIC	T4b	N0	M0	B	B3
IIIA	T1-T2	N1/N1c	M0	C	C1
	T1	N2a	M0	C	C1
IIIB	T3-T4a	N1/N1c	M0	C	C2
	T2-T3	N2a	M0	C	C1/C2
IIIC	T1-T2	N2b	M0	C	C1
	T4a	N2a	M0	C	C2
	T3-T4a	N2b	M0	C	C2
IVB	T4b	N1-N2	M0	C	C3
	Any T	Any N	M1a	-	-
IVA	Any T	Any N	M1b	-	-

Note: cTNM is the clinical classification, pTNM is the pathologic classification. The y prefix is used for those cancers that are classified after neoadjuvant pretreatment (e.g., ypTNM). Patients who have a complete pathologic response are ypT0N0cM0 that may be similar to Stage Group 0 or I. The r prefix is to be used for those cancers that have recurred after a disease-free interval (rTNM).

\*Dukes B is a composite of better (T3 N0 M0) and worse (T4 N0 M0) prognostic groups, as is Dukes C (Any TN1 M0 and Any T N2 M0). MAC is the modified Astler-Coller classification.



### Discussion

This discussion is being updated to correspond with the newly updated algorithm. Last updated 11/26/12

#### NCCN Categories of Evidence and Consensus

**Category 1:** Based upon high-level evidence, there is uniform NCCN consensus that the intervention is appropriate.

**Category 2A:** Based upon lower-level evidence, there is uniform NCCN consensus that the intervention is appropriate.

**Category 2B:** Based upon lower-level evidence, there is NCCN consensus that the intervention is appropriate.

**Category 3:** Based upon any level of evidence, there is major NCCN disagreement that the intervention is appropriate.

**All recommendations are category 2A unless otherwise noted.**

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### Overview

Colorectal cancer is the fourth most frequently diagnosed cancer and the second leading cause of cancer death in the United States. In 2012, an estimated 103,170 new cases of colon cancer and approximately 40,290 cases of rectal cancer will occur. During the same year, an estimated 51,690 people will die of colon and rectal cancer combined.<sup>1</sup> Despite these high numbers, the incidence of colon and rectal cancers per 100,000 people has decreased from 60.5 in 1976 to 46.4 in 2005.<sup>2</sup> In addition, mortality from colorectal cancer has decreased by almost 35% from 1990 to 2007,<sup>3</sup> possibly because of earlier diagnosis through screening and better treatment modalities.

This Discussion summarizes the NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines) for managing colon cancer. These guidelines begin with the clinical presentation of the patient to the primary care physician or gastroenterologist and address diagnosis, pathologic staging, surgical management, perioperative treatment, patient surveillance, management of recurrent and metastatic disease, and survivorship. When reviewing these guidelines, clinicians should be aware of several things. First, these guidelines adhere to the TNM staging system (Table 1 in the guidelines).<sup>4</sup> Furthermore, all recommendations are classified as category 2A except where noted in the text or algorithm. Although the guidelines are believed to represent the optimal treatment strategy, the panel believes that, when appropriate, patients should preferentially be included in a clinical trial over standard or accepted therapy.

### Risk Assessment

Approximately 20% of cases of colon cancer are associated with familial clustering,<sup>5,6</sup> and first-degree relatives of patients with newly diagnosed colorectal adenomas<sup>7</sup> or invasive colorectal cancer<sup>8</sup> are at increased

risk for colorectal cancer. Genetic susceptibility to colorectal cancer includes well-defined inherited syndromes, such as Lynch syndrome (also known as hereditary nonpolyposis colorectal cancer)<sup>9,10</sup> and familial adenomatous polyposis.<sup>11</sup> Therefore, it is recommended that all patients with colon cancer be queried regarding their family history and considered for risk assessment, as detailed in the NCCN Guidelines for Colorectal Cancer Screening (to view the most recent version of these guidelines, visit the NCCN Web site at [www.NCCN.org](http://www.NCCN.org)).

Lynch syndrome is the most common form of genetically determined colon cancer predisposition, accounting for 2% to 4% of all colorectal cancer cases.<sup>9,10,12,13</sup> This hereditary syndrome results from germline mutations in DNA mismatch repair (MMR) genes (*MLH1*, *MSH2*, *MSH6*, and *PMS2*). Although identifying a germline mutation in an MMR gene through sequencing is definitive for Lynch syndrome, patients usually undergo selection by considering family history and performing an initial test on tumor tissue before sequencing. One of two different initial tests can be performed on colorectal cancer specimens to identify individuals who might have Lynch syndrome: immunohistochemical analysis for MMR protein expression, which is often diminished because of mutation, or analysis for microsatellite instability (MSI), which results from MMR deficiency and is detected as changes in the length of repetitive DNA elements in tumor tissue caused by the insertion or deletion of repeated units.<sup>14</sup> Testing the *BRAF* gene for mutation is indicated when immunohistochemical analysis shows that *MLH1* protein expression is absent in the tumor. The presence of a *BRAF* mutation indicates that *MLH1* gene expression is down-regulated through somatic methylation of the promoter region of the gene and not through a germline mutation.<sup>14</sup>

The panel recommends that MMR protein testing be performed for all patients younger than 50 years with colon cancer, based on an

increased likelihood of Lynch syndrome in this population.<sup>15</sup> MMR testing should also be considered for patients with stage II tumors, as discussed in *Microsatellite Instability*, below. Some centers, however, now perform immunohistochemistry (and sometimes MSI) testing on all colorectal tumors to determine which patients should have genetic testing for Lynch syndrome. The cost effectiveness of this so-called reflex testing approach has been confirmed for colorectal cancer, and this approach was endorsed by the Evaluation of Genomic Applications in Practice and Prevention (EGAPP) working group at the Centers for Disease Control and Prevention (CDC).<sup>16</sup> A more detailed discussion is available in the NCCN Guidelines for Colorectal Cancer Screening (available online at [www.NCCN.org](http://www.NCCN.org)).

### Staging

The 7<sup>th</sup> edition of the American Joint Committee on Cancer's (AJCC) Cancer Staging Manual includes several modifications to the colon cancer TNM staging system.<sup>4,17,18</sup> The TNM categories reflect very similar survival outcomes for rectal and colon cancer. Therefore, these diseases share the same staging system.<sup>19</sup>

In the previous version (6<sup>th</sup> edition) of the AJCC staging system for colon cancer, stage II disease, characterized by full-thickness tumor invasion of the bowel wall and the absence of lymph node metastases (ie, N0 disease), was subdivided into IIA and IIB depending on whether the primary tumor was T3 or T4. Stage II disease is now subdivided into IIA (T3 lesions that invade through the muscularis propria into pericolorectal tissues), IIB (T4a lesions that directly penetrate to the surface of the visceral peritoneum), and IIC (T4b lesions where tumor directly invades or is adherent to other organs or structures).<sup>4</sup> These changes are supported by an analysis of 109,953 patients with invasive colon cancer included in the Surveillance Epidemiology and End

Results (SEER) colon cancer database from 1992–2004.<sup>20</sup> The relative 5-year survival rate (ie, 5-year survival corrected by age-related morbidity) was considerably higher (79.6%) for node-negative patients with T4 tumors that penetrated the visceral peritoneum compared with patients with tumors that invaded or were adherent to other organs (58.4%).<sup>20</sup>

The definitions of N1 and N2 disease have also been revised to reflect the prognostic impact of the number of involved regional lymph nodes. For example, N1 lesions (1 to 3 positive regional lymph nodes) have been subdivided into N1a (1 positive lymph node) and N1b (2 to 3 positive lymph nodes), whereas N2 tumors (4 or more positive regional nodes) have been split into N2a (4 to 6 positive nodes) and N2b (7 or more positive nodes). In addition, tumor deposit(s) in the subserosa, mesentery, or non-peritonealized pericolic or perirectal tissues without regional nodal metastasis (ie, satellite tumor nodules) have been classified as N1c.<sup>4</sup> See the *Pathology* section below for a discussion of tumor deposits.

Based on the analyses described above,<sup>20</sup> stage III disease, previously subdivided into IIIA (T1 to T2, N1, M0), IIIB (T3 to T4, N1, M0), and IIIC (any T, N2, M0), has been revised to more accurately reflect the complex biologic relationship between the extent of tumor invasion and the number of affected lymph nodes. For example, because of the relatively high survival rates observed for patients with lesions with extensive nodal involvement but no tumor penetration beyond the muscularis propria, T1-2, N2 lesions are now classified as either IIIA (T1, N2a) or IIIB (T2, N2a or T1-2, N2b). In addition, T4b, N1 disease, formerly stage IIIB disease, is now included under stage IIIC, because outcomes for these patients were found to be similar to those observed for patients with T3-4, N2 lesions.<sup>20</sup>

Stage IV disease is characterized by the presence of 1 or more distant metastases and is designated as M1.<sup>17</sup> M1 disease is now dichotomized into M1a and M1b according to whether metastasis is confined to 1 or more than 1 organ or site.<sup>4</sup>

### Pathology

Colorectal cancers are usually staged after surgical exploration of the abdomen and pathologic examination of the surgical specimen. Some of the criteria that should be included in the report of the pathologic evaluation include the following: grade of the cancer; depth of penetration and extension to adjacent structures (T); number of regional lymph nodes evaluated; number of positive regional lymph nodes (N); an assessment of the presence of distant metastases to other organs, to the peritoneum or an abdominal structure, or in non-regional lymph nodes (M)<sup>17,21</sup>; the status of proximal, distal, and radial margins<sup>17,22</sup>; lymphovascular invasion<sup>4,23,24</sup>; perineural invasion (PNI)<sup>25-27</sup>; and extranodal tumor deposits.<sup>28,29</sup> The prefixes “p” and “yp” used in TNM staging denote “pathologic staging” and “pathologic staging after neoadjuvant therapy and surgery,” respectively.<sup>4</sup>

In colon cancer, the radial margin (or circumferential resection margin, CRM) represents the adventitial soft tissue closest to the deepest penetration of the tumor. It is created surgically by blunt or sharp dissection of the retroperitoneal aspect, and it corresponds to any aspect of the colon that is not covered by a serosal layer of mesothelial cells.<sup>24</sup> It must be dissected from the retroperitoneum to remove the viscus. The serosal (peritoneal) surface does not constitute a surgical margin. The radial margins should be assessed in all colonic segments with non-peritonealized surfaces. In segments of the colon that are completely encased by peritoneum, such as the transverse colon, the mesenteric resection margin is the only relevant radial margin.<sup>24</sup> On

pathological examination, it is difficult to appreciate the demarcation between the peritonealized surface and the non-peritonealized surface. The surgeon is therefore encouraged to mark the area of non-peritonealized surface with a clip or suture.<sup>4</sup> In a study of 608 patients with rectal cancer, a positive radial margin was shown to be a negative prognostic factor for both local recurrence and overall survival (OS).<sup>30</sup> CRM-positive patients had a 38.2% local recurrence rate, whereas their CRM-negative counterparts had a 10.0% local recurrence rate.<sup>30</sup> The 7<sup>th</sup> edition of the AJCC staging system specifies that the surgeon should score the completeness of resection as R0 for complete tumor resection with all margins negative; R1 for incomplete tumor resection with microscopic involvement of a margin; and R2 for incomplete tumor resection with gross residual tumor not resected.<sup>4</sup>

Extranodal tumor deposits, also called peritumoral deposits or satellite nodules, are irregular discrete tumor deposits in the pericolic or perirectal fat that show no evidence of residual lymph node tissue, but are within the lymphatic drainage of the primary tumor. They are not counted as lymph nodes replaced by tumor. Most of these tumor deposits are thought to arise from lymphovascular invasion or, occasionally, PNI.<sup>31,32</sup> The number of extranodal tumor deposits should be recorded in the pathology report, because they have been shown to be associated with reductions in disease-free survival (DFS) and OS.<sup>28,29,33</sup> Multivariate survival analysis in one study showed that patients with pN0 tumors without satellite nodules had a 91.5% 5-year survival rate compared with a 37.0% 5-year survival rate for patients with pN0 tumors and the presence of satellite nodules ( $P < .0001$ ).<sup>29</sup>

The number of lymph nodes evaluated is important to note on the pathology report. A secondary analysis of patients from the Intergroup Trial INT-0089 showed that an increase in the number of lymph nodes examined was associated with increased survival for patients with both

node-negative and node-positive disease.<sup>34</sup> In addition, results from a population-based study showed an association between improvement in survival and examination of  $\geq 12$  lymph nodes.<sup>35</sup> The mechanism for this correlation is poorly understood. It has been hypothesized that the analysis of more lymph nodes would result in more accurate staging and thus better tailored treatments, but recent results suggest that this idea is not correct.<sup>36,37</sup> Instead it is likely that other factors associated with lymph node harvest are important for the survival advantage. For instance, the extent and quality of surgical resection can have an impact on the node harvest.<sup>38</sup> The number of regional lymph nodes retrieved from a surgical specimen also varies with age of the patient, gender, and tumor grade or site.<sup>34,35,39</sup> In addition, it has been suggested that lymph nodes in patients with a strong anti-cancer immune response are easier to find, and that such patients have an improved prognosis.<sup>40</sup> Another possibility is that the underlying tumor biology affects lymph node yield and prognosis in parallel. For instance, MSI has been associated with both improved prognosis and increased lymph node retrieval.<sup>41</sup>

Regardless of the mechanism for the observed correlation, the panel recommends examination of a minimum of 12 lymph nodes. This recommendation is supported by previous statements from the College of American Pathologists (CAP),<sup>24</sup> and recommendations included in the 7<sup>th</sup> edition of the AJCC staging manual,<sup>4</sup> which specify pathologic examination of a minimum of 10 to 14 lymph nodes. Notably, emerging evidence suggests that a greater number of nodes may need to be examined in some situations, particularly for T4 lesions, to provide an adequate assessment of disease stage.<sup>24,42</sup> For stage II (pN0) colon cancer, it is recommended that the pathologist go back to the specimen and submit more tissue of potential lymph nodes if fewer than 12 nodes were initially identified. Patients considered to have N0 disease but for

whom  $< 12$  nodes have been examined are suboptimally staged and should be considered to be at higher risk.

The potential benefit of sentinel lymph node evaluation for colon cancer has mostly been associated with providing more accurate staging of nodal pathology through detection of micrometastatic disease in the sentinel node(s).<sup>43</sup> Results of studies evaluating the sentinel node for micrometastatic disease through use of hematoxylin and eosin (H&E) staining to identify small foci of tumor cells and the identification of particular tumor antigens through immunohistochemical analysis have been reported.<sup>43-49</sup> Although results of some of these studies seem promising to some, no uniformity in the definition of “true” clinically relevant metastatic carcinoma exists. The 7<sup>th</sup> edition of the AJCC Cancer Staging Manual considers “tumor clusters” smaller than 0.2 mm to be isolated tumor cells and not true metastases.<sup>4</sup> However, some studies have considered detection of single cells through immunohistochemistry to be micrometastasis.<sup>50</sup> The prognostic value of positive cells by immunohistochemistry in stage II (N0 by H&E) colon cancer remains controversial.<sup>45,51,52</sup> Presently, the use of sentinel lymph nodes and detection of cancer cells through immunohistochemistry alone should be considered investigational, and the results should not be given significant weight in clinical management decisions.

There is also potential benefit of assessing regional lymph nodes for isolated tumor cells. One study of 312 consecutive pN0 patients found that positive cytokeratin staining was associated with a higher risk of recurrence.<sup>53</sup> Relapse occurred in 14% of patients with positive nodes compared to 4.7% of those with negative nodes (HR, 3.00; 95% CI, 1.23 to 7.32;  $P = .013$ ). A recent systematic review and meta-analysis came to a similar conclusion, finding decreased survival in pN0 patients with immunohistochemical or reverse transcriptase polymerase chain reaction (RT-PCR) evidence of tumor cells in regional nodes.<sup>54</sup> As with

sentinel nodes, the molecular detection of cancer cells in regional nodes should be considered investigational, and the results should be used with caution in clinical management decisions.

Several studies have shown that the presence of PNI is associated with a significantly worse prognosis.<sup>25-27</sup> For example, one retrospective analysis of 269 consecutive patients who had colorectal tumors resected at one institution found a 4-fold greater 5-year survival in patients without PNI versus patients whose tumors invaded nearby neural structures.<sup>26</sup> Multivariate analysis of patients with stage II rectal cancer showed that patients with PNI have a significantly worse 5-year DFS compared with those without PNI (29% vs. 82%;  $P = .0005$ ).<sup>27</sup> Similar results were seen for patients with stage III disease.<sup>25</sup> PNI is therefore included as a high-risk factor for systemic recurrence.

### The Role of Vitamin D in Colorectal Cancer

Prospective studies have suggested that vitamin D deficiency may contribute to colorectal cancer incidence and that vitamin D supplementation may decrease colorectal cancer risk.<sup>55-58</sup> Furthermore, 3 prospective studies showed that low vitamin D levels were associated with increased mortality of patients with colorectal cancer, especially in stage III and IV disease.<sup>59,60</sup> Moreover, in a study of 515 patients with stage IV colorectal cancer, 82% were found to be vitamin D-insufficient (levels <30 ng/mL) and 50% were found to be vitamin D-deficient (levels <20 ng/mL).<sup>61</sup> Nonetheless, no study has yet examined whether vitamin D supplementation improves patient outcomes. In a recent report, the Institute of Medicine concluded that data supporting a role for vitamin D were only conclusive in bone health, not in cancer and other diseases.<sup>62</sup> Citing this report and the lack of level 1 evidence, the panel does not currently recommend routine screening for vitamin D deficiency or supplementation of vitamin D in patients with colorectal cancer.

## Clinical Presentation and Treatment of Nonmetastatic Disease

### Workup and Management of the Malignant Polyp

A malignant polyp is defined as one with cancer invading the submucosa (pT1). Conversely, polyps classified as carcinoma in situ (pTis) have not penetrated the submucosa and are therefore not considered capable of regional nodal metastasis.<sup>17</sup> The panel recommends marking the polyp site during colonoscopy if cancer is suspected or within 2 weeks of the polypectomy when the pathology is known.

Before making a decision about surgical resection for an endoscopically resected adenomatous polyp or adenoma, physicians should review the pathology and consult with the patient.<sup>63</sup> In patients with invasive cancer or adenoma (tubular, tubulovillous, or villous), no additional surgery is required if the polyp has been completely resected and has favorable histologic features.<sup>64</sup> Favorable histologic features include lesions of grade 1 or 2, no angiolymphatic invasion, and a negative resection margin. However, in addition to the option of observation, the panel includes the option of colectomy in patients with a completely removed, single-specimen, sessile polyp with favorable histologic features and clear margins. This option is included because the literature seems to indicate that patients with sessile polyps may have a significantly greater incidence of adverse outcomes, including disease recurrence, mortality, and hematogenous metastasis compared with those with pedunculated polyps. This increased incidence likely occurs because of the high probability of a positive margin after endoscopic removal.<sup>65-67</sup>

If the polyp specimen is fragmented, the margins cannot be assessed, or the specimen shows unfavorable histopathology, colectomy with en bloc removal of lymph nodes is recommended.<sup>63,68,69</sup> Laparoscopic

surgery is an option.<sup>70</sup> Unfavorable histopathologic features for malignant polyps include grade 3 or 4, angiolymphatic invasion, or a positive margin of resection. Notably, no consensus currently exists as to the definition of what constitutes a positive margin of resection. A positive margin has been defined as the presence of tumor within 1 to 2 mm of the transected margin or the presence of tumor cells within the diathermy of the transected margin.<sup>63,71-73</sup>

All patients who have resected polyps should undergo total colonoscopy to rule out other synchronous polyps, and should subsequently undergo appropriate follow-up surveillance endoscopy.<sup>74</sup> Adjuvant chemotherapy is not recommended for patients with stage I lesions.

### Workup and Management of Invasive Nonmetastatic Colon Cancer

Patients who present with invasive colon cancer appropriate for resection require a complete staging workup, including pathologic tissue review, total colonoscopy, CBC, chemistry profile, carcinoembryonic antigen (CEA) determination, and baseline CT scans of the chest, abdomen, and pelvis.<sup>75</sup> CT should be with IV and oral contrast. If the CT of the abdomen and pelvis is inadequate or if CT with IV contrast is contraindicated, an abdominal/pelvic MRI with contrast plus a non-contrast chest CT should be considered. The consensus of the panel is that a PET/CT scan is not routinely indicated at baseline for preoperative workup. In fact, PET/CT scans are usually done without contrast and multiple slicing and do not obviate the need for a contrast-enhanced diagnostic CT scan. If, however, abnormalities are seen on CT or MRI scan that are considered suspicious but inconclusive for metastases, then a PET/CT scan may be considered to further delineate that abnormality, if this information will change management.

A PET/CT scan is not indicated for assessing sub-centimeter lesions, because these are routinely below the level of PET/CT detection.

For resectable colon cancer that is causing overt obstruction, resection with diversion, stent insertion followed by colectomy, or diversion followed by colectomy are options. Stents are only used as a temporary measure to avoid colostomy in patients for whom surgery is planned. If the cancer is locally unresectable or the patient is medically inoperable, chemotherapy is recommended, possibly with the goal of converting the lesion to a resectable state.

### Surgical Management

For resectable non-metastatic colon cancer, the preferred surgical procedure is colectomy with en bloc removal of the regional lymph nodes.<sup>76,77</sup> The extent of colectomy should be based on the tumor location, resecting the portion of the bowel and arterial arcade containing the regional lymph nodes. Other nodes, such as those at the origin of the vessel feeding the tumor (ie, apical lymph node), and suspicious lymph nodes outside the field of resection, should also be biopsied or removed if possible. Resection must be complete to be considered curative, and positive lymph nodes left behind indicate an incomplete (R2) resection.<sup>4,78</sup>

There has been some recent attention focused on the quality of colectomy.<sup>79</sup> A retrospective observational study found a possible OS advantage for surgery in the mesocolic plane over surgery in the muscularis propria plane.<sup>80</sup> Recently, a comparison of resection techniques by expert surgeons in Japan and Germany showed that complete mesocolic excision with central vascular ligation resulted in greater mesentery and lymph node yields than the Japanese D3 high tie surgery.<sup>81</sup> Differences in outcomes were not reported.

Laparoscopic colectomy is an option in the surgical management of colon cancer.<sup>82</sup> In a small European randomized trial (Barcelona), the laparoscopic approach seemed to be associated with some modest survival advantage, significantly faster recovery, and shorter hospital stays.<sup>83</sup> More recently, a similar larger trial (COLOR trial) of 1248 patients with colon cancer randomly assigned to curative surgery with either a conventional open approach or laparoscopic-assisted surgery showed a nonsignificant absolute difference of 2.0% in 3-year DFS favoring open colectomy.<sup>84</sup> Non-inferiority of the laparoscopic approach could not be established because of study limitations.<sup>84</sup> In the CLASICC study of 794 patients with colorectal cancer, no statistically significant differences in 3-year rates of OS, DFS, and local recurrence were observed between these surgical approaches.<sup>85</sup>

In another trial of 872 patients with colon cancer (COST study) randomly assigned to undergo either open or laparoscopic-assisted colectomy for curable colon cancer,<sup>86,87</sup> similar 5-year recurrence and 5-year OS rates were seen after a median of 7 years follow-up. In addition, results of several recent meta-analyses have supported the conclusion that the 2 surgical approaches provide similar long-term outcomes with respect to local recurrence and survival in patients with colon cancer.<sup>88-91</sup>

A subanalysis of results from the COLOR trial evaluating short-term outcomes (eg, conversion rate to open colectomy, number of lymph nodes collected, number of complications) based on hospital case volume indicated that these outcomes were statistically significantly more favorable when laparoscopic surgery was performed at hospitals with high case volumes.<sup>92</sup> Other factors have been described that may confound conclusions drawn from randomized studies comparing open colectomy with laparoscopic-assisted surgery for colon cancer.<sup>93,94</sup>

The panel recommends that laparoscopic-assisted colectomy be considered only by surgeons experienced in the technique. A thorough abdominal exploration is required as part of the procedure. Routine use of laparoscopic-assisted resection is not currently recommended for tumors in the lower and mid rectum, tumors that are acutely obstructed or perforated, or tumors that are clearly locally invasive into surrounding structures (ie, T4). Patients at high risk for prohibitive abdominal adhesions should not be approached laparoscopically, and those who are found to have prohibitive adhesions during laparoscopic exploration should be converted to an open procedure.<sup>70,95,96</sup>

### Adjuvant Chemotherapy for Resectable Colon Cancer

Adjuvant therapy for patients with resected colon cancer has gained considerable interest.<sup>97</sup> Choices for adjuvant therapy for patients with resected nonmetastatic colon cancer depend on the stage of disease:

- Patients with stage I disease do not require any adjuvant therapy.
- Patients with low-risk stage II disease can be enrolled in a clinical trial, observed without adjuvant therapy, or considered for capecitabine or 5-FU/leucovorin (LV). Based on results of the MOSAIC trial,<sup>98-101</sup> and the possible long-term sequelae of oxaliplatin-based chemotherapy, the panel does not consider FOLFOX (infusional 5-FU, LV, oxaliplatin) to be an appropriate adjuvant therapy option for patients with stage II disease without high-risk features.
- Patients with high-risk stage II disease, defined as those with poor prognostic features, including T4 tumors (stage IIB/IIC); poorly differentiated histology (exclusive of those cancers that are MSI-high [MSI-H]); lymphovascular invasion; PNI; bowel



obstruction; lesions with localized perforation or close, indeterminate, or positive margins; or inadequately sampled nodes (<12 lymph nodes), can be considered for adjuvant chemotherapy with 5-FU/LV, capecitabine, FOLFOX, capecitabine/oxaliplatin (CapeOx), or FLOX.<sup>22,102</sup> Observation without adjuvant therapy is also an option in this population. The factors in decision making for stage II adjuvant therapy are discussed in more detail below.

- For patients with stage III disease, the panel recommends 6 months of adjuvant chemotherapy after primary surgical treatment.<sup>103</sup> The treatment options are FOLFOX<sup>98-101,104</sup> or CapeOx<sup>105,106</sup> (both category 1 and preferred); bolus 5-FU/LV/oxaliplatin (FLOX, category 1)<sup>107</sup>; or single-agent capecitabine<sup>108</sup> or 5-FU/LV in patients for whom oxaliplatin therapy is believed to be inappropriate.<sup>109-112</sup>

The panel recommends against the use of bevacizumab, cetuximab, panitumumab, or irinotecan in adjuvant therapy for nonmetastatic disease outside the setting of a clinical trial. Adenocarcinomas of the small bowel or appendix, for which no NCCN Guidelines exist, may be treated with systemic chemotherapy according to these guidelines. Peritoneal mesothelioma and other extrapleural mesotheliomas may be treated with systemic therapy according to NCCN Guidelines for pleural mesothelioma.

#### **End Points for Adjuvant Chemotherapy Clinical Trials**

The Adjuvant Colon Cancer End Points (ACCENT) collaborative group evaluated the appropriateness of various end points for adjuvant chemotherapy trials in colon cancer. Results of an analysis of individual patient data from 20,898 patients in 18 randomized colon adjuvant clinical trials by the ACCENT group suggested that DFS after 2 and 3

years follow-up is an appropriate end point for clinical trials involving treatment of colon cancer with 5-FU-based chemotherapy in the adjuvant setting.<sup>113,114</sup> An update of this analysis showed that most relapses occur within 2 years after surgery, and that recurrence rates were less than 1.5% per year and less than 0.5% per year after 5 and 8 years, respectively.<sup>115</sup> More recently, however, a further update of the data suggested that the association between 2- or 3-year DFS and 5-year OS was reduced when patient survival after recurrence was hypothetically prolonged to match the current time to survival from recurrence seen with modern combination therapies (2 years), and that more than 5 years may now be required to evaluate the effect of adjuvant therapies on OS.<sup>116</sup> Further confirmation of this result comes from new analysis by the ACCENT group of data from 12,676 patients undergoing combination therapies from 6 trials.<sup>117</sup> This study determined that 2- and 3-year DFS correlated with 5- and 6-year OS in patients with stage III disease but not in those with stage II disease. In all patients, the correlation of DFS to OS was strongest at 6-year follow-up, suggesting that at least 6 years are required for adequate assessment of OS in modern adjuvant colon cancer trials.<sup>117</sup>

#### **Adjuvant Chemotherapy in Stage II Disease**

The impact of adjuvant chemotherapy for patients with stage II colon cancer has been addressed in several clinical trials and practice-based studies. Results from a meta-analysis of 5 trials in which patients with stage II or III colon cancer were randomly assigned to receive surgery alone or surgery followed by adjuvant 5-FU/LV showed that most of the benefit of adjuvant therapy was seen in the patients with stage III disease.<sup>109,118</sup> Similarly, an analysis of pooled data from 7 randomized trials indicated that OS of patients with resected colon cancer treated with 5-FU-based adjuvant therapy was statistically significantly increased with the addition of chemotherapy in the subset of patients

with stage III disease but not in those with stage II disease.<sup>119</sup> These results suggest that the benefit of adjuvant therapy is greater in patients at higher risk because of nodal status.<sup>119</sup> These clinical trial results are supported by data from the community setting. Using the SEER databases, an analysis of outcomes of patients with stage II disease based on whether or not they had received adjuvant chemotherapy showed no statistically significant difference in 5-year OS between the groups (78% vs. 75%, respectively), with a hazard ratio (HR) for survival of 0.91 (95% CI, 0.77-1.09) when patients receiving adjuvant treatment were compared with untreated patients.<sup>120</sup> In contrast to results from most other trials, the QUASAR trial indicated a small but statistically significant survival benefit for patients with stage II disease treated with 5-FU/LV compared to patients not receiving adjuvant therapy (relative risk of recurrence at 2 years, 0.71; 95% CI, 0.54-0.92;  $P = .01$ ).<sup>121</sup>

A recent meta-analysis of 12 randomized controlled trials from 1988 to 2010 in which surgery alone was the control arm found a significant benefit to adjuvant therapy in patients with stage II colon cancer.<sup>122</sup> The 5-year OS HR was 0.81 (95% CI, 0.71-0.91), and the 5-year DFS HR was 0.86 (95% CI, 0.75-0.98). The trials in this analysis used various chemotherapy regimens, many of which are not currently recommended for this setting.

Notably, a recent analysis of more than 24,000 patients with stage II colon cancer from the SEER Medicare database showed no 5-year survival benefit for adjuvant chemotherapy over observation, even in patients with stage II disease with one or more poor prognostic features (HR, 1.03; 95% CI, 0.94-1.13).<sup>123</sup> Although this study was limited to patients older than 65 years and involved a period before the use of oxaliplatin-based therapies,<sup>124</sup> it is still an important piece of data to consider during the decision-making process regarding the use of adjuvant chemotherapy in patients with stage II disease.

The benefit of oxaliplatin in adjuvant therapy for patients with stage II colon cancer has also been addressed. Results from a recent post-hoc exploratory analysis of the MOSAIC trial did not show a significant DFS benefit of FOLFOX over 5-FU/LV for patients with stage II disease at a follow-up of 6 years (HR, 0.84; 95% CI, 0.62 to 1.14;  $P = .258$ ).<sup>125</sup> In addition, patients with high-risk stage II disease (ie, disease characterized by at least one of the following: T4 tumor; tumor perforation; bowel obstruction; poorly differentiated tumor; venous invasion; <10 lymph nodes examined) receiving FOLFOX did not have improved DFS compared with those receiving infusional 5-FU/LV (HR, 0.72; 95% CI, 0.50-1.02;  $P = .063$ ). Furthermore, no OS benefit was seen in the stage II population overall or stage II with high-risk features. Similar results were seen in the C-07 trial, which compared FLOX to 5-FU/LV in stage II and III patients.<sup>126</sup>

Decision making regarding the use of adjuvant therapy for patients with stage II disease should incorporate patient/physician discussions individualized for the patient, and should include explanations of the specific characteristics of the disease and its prognosis and the evidence related to the efficacy and possible toxicities associated with treatment, centering on patient choice.<sup>102,127</sup> Observation and participation in a clinical trial are options that should be considered. Patients with average-risk stage II colon cancer have a very good prognosis, so the possible benefit of adjuvant therapy is small. Patients with high-risk features, on the other hand, have been traditionally considered more likely to benefit from adjuvant chemotherapy. However, the current definition of high-risk stage II colon cancer is clearly inadequate, in that many high-risk patients do not have a recurrence while some average-risk patients do.<sup>128</sup> Furthermore, no data point to features that are predictive of benefit from adjuvant chemotherapy, and no data correlate risk features and selection of

chemotherapy in high-risk stage II patients. Overall, the NCCN Panel supports the conclusion of a 2004 ASCO Panel and believes that it is reasonable to accept the relative benefit of adjuvant therapy in stage III disease as indirect evidence of benefit for stage II disease, especially for those with high-risk features.<sup>102</sup>

Additional information that may influence adjuvant therapy decisions in stage II and/or stage III disease (MSI, multigene assays, and the influence of patient age) is discussed below.

### *Microsatellite Instability*

MSI is another important piece of information to consider when deciding whether to use adjuvant chemotherapy in patients with stage II disease. Evidence shows that MSI is a marker of a more favorable outcome and a predictor of decreased benefit (possibly a detrimental impact) from adjuvant therapy with a fluoropyrimidine alone in patients with stage II disease.<sup>129,130</sup> Mutation of MMR genes or modifications of these genes (eg, methylation) can result in MMR protein deficiency and MSI (see *Risk Assessment*, above).<sup>131</sup>

Germline mutations in the MMR genes *MLH1*, *MSH2*, *MSH6*, and/or *PMS2* are found in individuals with Lynch syndrome, which is responsible for 2% to 4% of colon cancer cases.<sup>9,10,12,13</sup> Somatic MMR defects have been reported to occur in approximately 19% of colorectal tumors,<sup>132</sup> whereas others have reported somatic hypermethylation of the *MLH1* gene promoter, which is associated with *MLH1* gene inactivation, in as many as 52% of colon tumors.<sup>133</sup> Tumors showing the presence of MSI are classified as either MSI-H or MSI-low (MSI-L), depending on the extent of instability in the markers tested, whereas tumors without this characteristic are classified as microsatellite-stable (MSS).<sup>134</sup> Patients determined to have defective MMR (dMMR) status are biologically the same population as those with MSI-H status.

Data from the PETACC-3 trial showed that tumor specimens characterized as MSI-H are more common in stage II disease than in stage III disease (22% vs. 12%, respectively;  $P < .0001$ ).<sup>135</sup> In another large study, the percentage of stage IV tumors characterized as MSI-H was only 3.5%.<sup>136</sup> These results suggest that MSI-H (ie, dMMR) tumors have a decreased likelihood to metastasize. In fact, substantial evidence shows that in patients with stage II disease, a deficiency in MMR protein expression or MSI-H tumor status is a prognostic marker of a more favorable outcome.<sup>129,130,137</sup>

However, some of these same studies also show that a deficiency in MMR protein expression or MSI-H tumor status may be a predictive marker of decreased benefit (possibly a detrimental impact) from adjuvant therapy with a fluoropyrimidine alone in patients with stage II disease.<sup>129,130</sup> A retrospective study involving long-term follow-up of patients with stage II and III disease evaluated according to MSI tumor status showed that those characterized as MSI-L or MSS had improved outcomes with 5-FU adjuvant therapy. However, patients with tumors characterized as MSI-H did not show a statistically significant benefit from 5-FU after surgery, instead exhibiting a lower 5-year survival rate than those undergoing surgery alone.<sup>129</sup> Similarly, results from another retrospective study of pooled data from adjuvant trials by Sargent et al<sup>130</sup> showed that in tumors characterized as dMMR, adjuvant 5-FU chemotherapy seemed to be detrimental in patients with stage II disease, but not in those with stage III disease.

In contrast to the findings of Sargent et al, [Sargent, 2010 #278] however, a recent study of 1913 patients with stage II colorectal cancer from the QUASAR study, half of whom received adjuvant chemotherapy, showed that although dMMR was prognostic (the recurrence rate of dMMR tumors was 11% vs. 26% for MMR-proficient tumors), it did not predict benefit or detrimental impact of

chemotherapy.<sup>138</sup> A recent study of patients on the CALGB 9581 and 89803 trials came to a similar conclusion.<sup>139</sup> MMR status was prognostic but not predictive of benefit or detrimental impact of adjuvant therapy (irinotecan plus bolus 5-FU/LV [IFL regimen]) in patients with stage II colon cancer.

Because stage II MSI-H patients may have a good prognosis and do not benefit from 5-FU adjuvant therapy, the panel recommends that MMR testing be considered for patients with stage II disease. Poorly differentiated histology is not considered a high-risk feature for patients with stage II disease whose tumors are MSI-H. In addition, MMR testing should be performed for all patients <50 years of age to assess for the possibility of Lynch syndrome.

### Multigene Assays

Several multigene assays have been developed in hopes of providing prognostic and predictive information to aid in decisions regarding adjuvant therapy in patients with stage II or III colon cancer.<sup>128</sup>

Oncotype DX colon cancer assay (Genomic Health, Inc.) quantifies the expression of 7 recurrence-risk genes and 5 reference genes as a prognostic classifier of low, intermediate, or high likelihood of recurrence.<sup>140</sup> Clinical validation in stage II and III patients from QUASAR<sup>141</sup> and National Surgical Adjuvant Breast and Bowel Project (NSABP) C-07<sup>142</sup> trials showed that recurrence scores are prognostic for recurrence, DFS, and OS in stage II and III colon cancer, but are not predictive of benefit to adjuvant therapy. For the low, intermediate, and high recurrence risk groups, recurrence at 3 years was 12%, 18%, and 22%, respectively.<sup>141</sup> Multivariate analysis showed that recurrence scores were related to recurrence independently from TNM staging, MMR status, tumor grade, and number of nodes assessed in both stage II and III disease.

ColoPrint (Agendia) quantifies the expression of 18 genes as a prognostic classifier of low versus high recurrence risk.<sup>143</sup> In a set of 206 patients with stage I through III colorectal cancer, the 5-year relapse-free survival rates were 87.6% (95% CI, 81.5% to 93.7%) and 67.2% (95% CI, 55.4% to 79.0%) for those classified as low- and high-risk, respectively. In patients with stage II disease in particular, the HR for recurrence between the high and low groups was 3.34 ( $P = .017$ ).<sup>143</sup> This assay was further validated in a pooled analysis of 320 stage II patients, 227 of whom were assessed as a T3/MSS subset.<sup>144</sup> In the T3/MSS subset, patients classified as low-risk and high-risk had 3-year recurrence-free survival rates of 91% (86%–96%) and 73% (63%–83%) ( $P = .002$ ), respectively.<sup>144</sup> As with the Oncotype DX colon cancer assay, recurrence risk determined by ColoPrint is independent of other risk factors, including T stage, perforation, number of nodes assessed, and tumor grade. This assay is being further validated for its ability to predict 3-year relapse rates in patients with stage II colon cancer in a prospective trial.<sup>145</sup>

ColDx is a microarray-based multigene assay that uses 634 probes to identify patients with stage II colon cancer at high risk of recurrence.<sup>146</sup> In a 144-sample independent validation set, the HR for identification of high-risk patients was 2.53 (95% CI, 1.54-4.15;  $P < .001$ ) for recurrence and 2.21 (95% CI, 1.22-3.97;  $P = .0084$ ) for cancer-related death. Similar to the other assays described here, the recurrence risk determined by ColDx is independent of other risk factors.

In summary, the information from these tests can further inform the risk of recurrence over other risk factors, but the panel questions the value added. Furthermore, there is no evidence of predictive value in terms of the potential benefit of chemotherapy to any of the available multigene assays. The panel believes that there are insufficient data to recommend the use of multigene assays to determine adjuvant therapy.

**Adjuvant Chemotherapy in Elderly Patients**

Adjuvant chemotherapy usage declines with the age of the patient.<sup>147</sup> Questions regarding the safety and efficacy of chemotherapy in older patients have been difficult to answer, because older patients are underrepresented in clinical trials. Some data speaking to these questions have been reviewed.<sup>148,149</sup>

Population studies have found that adjuvant therapy is beneficial in older patients. A retrospective analysis of 7263 patients from the linked SEER-Medicare Databases found a survival benefit for the use of 5-FU/LV in stage III patients 65 years or older (HR, 0.70;  $P < .001$ ).<sup>150</sup> Another analysis of 5489 patients aged  $\geq 75$  years diagnosed with stage III colon cancer between 2004 and 2007 from 4 datasets, including the SEER-Medicare Databases and the NCCN Outcomes Database, showed a survival benefit for adjuvant chemotherapy in this population (HR, 0.60; 95% CI, 0.53-0.68).<sup>147</sup> This study also looked specifically at the benefit of the addition of oxaliplatin to adjuvant therapy in these older stage III patients, and found only a small, non-significant benefit.

Subset analyses of major adjuvant therapy trials also show a lack of benefit to the addition of oxaliplatin in older patients. Subset analysis of the NSABP C-07 trial showed that the addition of oxaliplatin to 5-FU/LV gave no survival benefit in patients aged  $\geq 70$  years with stage II or III colon cancer ( $n=396$ ), with a trend towards decreased survival (HR, 1.18; 95% CI, 0.86-1.62).<sup>126</sup> Similarly, in a subset analysis of the MOSAIC trial, 315 patients aged 70–75 years with stage II or III colon cancer derived no benefit from the addition of oxaliplatin (OS HR, 1.10; 95% CI, 0.73-1.65).<sup>125</sup>

Overall, the benefit and toxicities of 5-FU/LV as adjuvant therapy seem to be similar in older and younger patients. However, the panel cautions that a benefit for the addition of oxaliplatin to 5-FU/LV in patients aged

70 years and older has not been proven in stage II or stage III colon cancer.

**Timing of Adjuvant Therapy**

A recent systematic review and meta-analysis of 10 studies involving more than 15,000 patients examined the effect of timing of adjuvant therapy after resection.<sup>151</sup> Results of this analysis showed that each 4-week delay in chemotherapy results in a 14% decrease in OS, indicating that adjuvant therapy should be administered as soon as the patient is medically able. These results are consistent with other similar analyses. However, some critics have pointed out that this type of analysis is biased by confounding factors such as comorbidities, which are likely to be higher in patients with a longer delay before initiation of chemotherapy.<sup>152</sup>

**Leucovorin Shortage**

A shortage of LV currently exists in the United States. No specific data are available to guide management under these circumstances, and all proposed strategies are empiric. The panel recommends several possible options to help alleviate the problems associated with this shortage. One is the use of levoleucovorin, which is commonly used in Europe. A dose of 200 mg/m<sup>2</sup> of levoleucovorin is equivalent to 400 mg/m<sup>2</sup> of standard LV. Another option is for practices or institutions to use lower doses of LV for all doses in all patients, because the panel feels that lower doses are likely to be as efficacious as higher doses, based on several studies. The QUASAR study found that 175 mg of LV was associated with similar survival and 3-year recurrence rates as 25 mg of LV when given with bolus 5-FU as adjuvant therapy to patients after R0 resections for colorectal cancer.<sup>153</sup> Another study showed no difference in response rate or survival in patients with metastatic colorectal cancer receiving bolus 5-FU with either high-dose (500 mg/m<sup>2</sup>) or low-dose (20 mg/m<sup>2</sup>) LV.<sup>154</sup> Furthermore, the Mayo Clinic and

North Central Cancer Treatment Group (NCCTG) determined that no therapeutic difference was seen between the use of high-dose (200 mg/m<sup>2</sup>) or low-dose (20 mg/m<sup>2</sup>) LV with bolus 5-FU in the treatment of advanced colorectal cancer, although the 5-FU doses were different in the treatment arms.<sup>155</sup> Finally, if none of the above options are available, treatment without LV would be reasonable. For patients who tolerate this without grade II or higher toxicity, a modest increase in 5-FU dose (in the range of 10%) may be considered.

### **FOLFOX and Infusional 5-FU/LV**

The European MOSAIC trial compared the efficacy of FOLFOX and 5-FU/LV in the adjuvant setting in 2246 patients with completely resected stage II and III colon cancer. Although this initial trial was performed with FOLFOX4, mFOLFOX6 has been the control arm for all recent and current National Cancer Institute (NCI) adjuvant studies for colorectal cancer, and the panel believes that mFOLFOX6 is the preferred FOLFOX regimen for adjuvant and metastatic treatments. Results of this study have been reported with median follow-ups of 3,<sup>98</sup> 4,<sup>99</sup> and 6 years.<sup>100,101</sup> For patients with stage III disease, DFS at 5 years was 58.9% in the 5-FU/LV arm and 66.4% in the FOLFOX arm ( $P = .005$ ), and OS of patients with stage III disease receiving FOLFOX was statistically significantly increased at 6-year follow-up (72.9% vs. 68.7%; HR, 0.80; 95% CI, 0.65-0.97;  $P = .023$ ) compared with those receiving 5-FU/LV.<sup>100</sup> Although the incidence of grade 3 peripheral sensory neuropathy was 12.4% for patients receiving FOLFOX and only 0.2% for patients receiving 5-FU/LV, long-term safety results showed a gradual recovery for most of these patients. However, neuropathy was present in 15.4% of this group at 4 years (mostly grade 1), suggesting that oxaliplatin-induced neuropathy may not be completely reversible in some patients.<sup>100</sup>

A recent analysis of 5 observational data sources, including the SEER-Medicare and NCCN Outcomes Databases, showed that the addition of oxaliplatin to 5-FU/LV gave a survival advantage to the general stage III colon cancer population treated in the community.<sup>156</sup> Another population-based analysis found that the harms of oxaliplatin in the medicare population with stage III colon cancer were reasonable, even in patients 75 years or older.<sup>157</sup>

Based on the increases in DFS and OS with FOLFOX in the MOSAIC trial, FOLFOX (mFOLFOX6 preferred) is recommended as a preferred treatment for stage III colon cancer (category 1).

### **FLOX**

A randomized phase III trial (NSABP Protocol C-07) compared the efficacy of FLOX (bolus 5-FU/LV/oxaliplatin) with that of FULV (bolus 5-FU/LV) in prolonging DFS in 2407 patients with stage II or III colon cancer.<sup>107</sup> Rates of 4-year DFS were 73.2% for FLOX and 67.0% for FULV, with an HR of 0.81 (95% CI, 0.69-0.94;  $P = .005$ ) after adjustment for age and number of nodes, indicating a 19% reduction in relative risk.<sup>107</sup> A recent update of this study showed that the benefit of FLOX in DFS was maintained at 7-year median follow-up ( $P = .0017$ ).<sup>126</sup> However, no statistically significant differences in OS (HR, 0.88; 95% CI, 0.76-1.03;  $P = .1173$ ) or colon-cancer-specific mortality (HR, 0.88; 95% CI, 0.74-1.05;  $P = .1428$ ) were observed when the arms were compared. Furthermore, survival after disease recurrence was significantly shorter in the group receiving oxaliplatin (HR, 1.20; 95% CI, 1.00-1.43;  $P = .0497$ ).<sup>126</sup>

Grade 3 neurotoxicity, diarrhea, and dehydration were higher with FLOX than with 5-FU/LV,<sup>126</sup> and, when cross-study comparisons were made, the incidence of grade 3/4 diarrhea seemed to be considerably higher with FLOX than with FOLFOX. For example, rates of grade 3/4 diarrhea

were 10.8% and 6.6% for patients receiving FOLFOX and infusional 5-FU/LV, respectively ( $P < .001$ ), in the MOSAIC trial,<sup>98</sup> whereas 38% and 32% of patients were reported to have grade 3/4 diarrhea in the NSABP C-07 trial when receiving FLOX and bolus 5-FU/LV, respectively ( $P = .003$ ).<sup>107</sup>

### **Capecitabine and CapeOx**

Single-agent oral capecitabine as adjuvant therapy for patients with stage III colon cancer was shown to be at least equivalent to bolus 5-FU/LV (Mayo Clinic regimen) with respect to DFS and OS with respective HRs of 0.87 (95% CI, 0.75-1.00,  $P < .001$ ) and 0.84 (95% CI, 0.69-1.01,  $P = .07$ ).<sup>108</sup> Final results of this trial were recently reported.<sup>158</sup> After a median follow-up of 6.9 years, the equivalencies in DFS and OS were maintained in all subgroups, including those 70 years of age or older.

Capecitabine was also assessed as adjuvant therapy for stage III colon cancer in combination with oxaliplatin (CapeOx) and showed an improved 3-year DFS rate compared with 5-FU/LV (66.5% vs. 70.9%).<sup>105,106</sup> CapeOx was shown to have similar efficacy to FOLFOX in the AVANT trial, but was found to be more toxic.<sup>159</sup> With these new data, CapeOx is now listed in the guidelines with a category 1 designation as a preferred adjuvant therapy for patients with stage III colon cancer.

### **Regimens Not Recommended**

Other adjuvant regimens studied for the treatment of early-stage colon cancer include 5-FU–based therapies incorporating irinotecan. The CALGB 89803 trial evaluated the IFL regimen versus 5-FU/LV alone in stage III colon cancer.<sup>160</sup> No improvement in either OS ( $P = .74$ ) or DFS ( $P = .84$ ) was observed for patients receiving IFL compared with those receiving 5-FU/LV. However, IFL was associated with a greater degree

of neutropenia, neutropenic fever, and death.<sup>160,161</sup> Similar results were observed in a recent randomized phase III trial comparing bolus 5-FU/LV with the IFL regimen in stage II/III colon cancer.<sup>162</sup> In addition, FOLFIRI (infusional 5-FU/LV/irinotecan) has not been shown to be superior to 5-FU/LV in the adjuvant setting.<sup>163,164</sup> Thus, data do not support the use of irinotecan-containing regimens in the treatment of stage II or III colon cancer.

In the NSABP C-08 trial comparing 6 months of mFOLFOX6 with 6 months of mFOLFOX6 with bevacizumab plus an additional 6 months of bevacizumab alone in patients with stage II or III colon cancer, no statistically significant benefit in 3-year DFS was seen with the addition of bevacizumab (HR, 0.89; 95% CI, 0.76-1.04;  $P = .15$ ).<sup>165</sup> The results of the phase III AVANT trial evaluating bevacizumab in the adjuvant setting in a similar protocol also failed to show a benefit associated with bevacizumab in the adjuvant treatment of stage II or III colorectal cancer, and in fact showed a trend toward a detrimental effect to the addition of bevacizumab. Therefore, bevacizumab has no role in the adjuvant treatment of stage II or III colon cancer.<sup>159</sup>

The NCCTG Intergroup phase III trial N0147 assessed the addition of cetuximab to FOLFOX in the adjuvant treatment of stage III colon cancer. In patients with wild-type or mutant *KRAS*, cetuximab provided no added benefit and was associated with increases in grade 3/4 adverse events.<sup>166</sup> In addition, all subsets of patients treated with cetuximab experienced increases in grade 3/4 adverse events. Therefore, cetuximab also has no role in the adjuvant treatment of colon cancer.

### **Adjuvant Chemoradiation**

Radiation therapy delivered concurrently with 5-FU-based chemotherapy may be considered for very select patients with disease



characterized as T4 tumors penetrating to a fixed structure or for patients with recurrent disease. Radiation therapy fields should include the tumor bed as defined by preoperative radiologic imaging and/or surgical clips. Intraoperative radiotherapy (IORT), if available, should be considered for these patients as an additional boost.<sup>167</sup> If IORT is not available, an additional 10 to 20 Gy of external beam radiation and/or brachytherapy could be considered to a limited volume. Preoperative radiation with concurrent 5-FU-based chemotherapy is also a consideration for these patients to aid resectability. If radiation therapy is to be used, conformal beam radiation should be the routine choice; intensity-modulated radiation therapy (IMRT), which uses computer imaging to focus radiation to the tumor site and potentially decrease toxicity to normal tissue,<sup>168</sup> should be reserved for unique clinical situations, including reirradiation of previously treated patients with recurrent disease.

### Principles of the Management of Metastatic Disease

Approximately 50% to 60% of patients diagnosed with colorectal cancer develop colorectal metastases,<sup>169-171</sup> and 80% to 90% of these patients have unresectable metastatic liver disease.<sup>170,172-175</sup> Metastatic disease most frequently develops metachronously after treatment for locoregional colorectal cancer, with the liver being the most common site of involvement.<sup>176</sup> However, 20% to 34% of patients with colorectal cancer present with synchronous liver metastases.<sup>175,177</sup> Some evidence indicates that synchronous metastatic colorectal liver disease is associated with a more disseminated disease state and a worse prognosis than metastatic colorectal liver disease that develops metachronously. In a retrospective study of 155 patients who underwent hepatic resection for colorectal liver metastases, patients with synchronous liver metastases had more sites of liver involvement ( $P =$

.008) and more bilobar metastases ( $P = .016$ ) than patients diagnosed with metachronous liver metastases.<sup>178</sup>

It has been estimated that more than half of patients who die of colorectal cancer have liver metastases at autopsy, with metastatic liver disease being the cause of death in most patients.<sup>179</sup> Reviews of autopsy reports of patients who died from colorectal cancer showed that the liver was the only site of metastatic disease in one-third of patients.<sup>174</sup> Furthermore, several studies have shown rates of 5-year survival to be low in patients with metastatic liver disease not undergoing surgery.<sup>170,180</sup> Certain clinicopathologic factors, such as the presence of extrahepatic metastases, the presence of more than 3 tumors, and a disease-free interval of less than 12 months, have been associated with a poor prognosis in patients with colorectal cancer.<sup>177,181-185</sup>

However, studies of selected patients undergoing surgery to remove colorectal liver metastases have shown that cure is possible in this population and should be the goal for a substantial number of these patients.<sup>170,186</sup> Recent reports have shown 5-year DFS rates of approximately 20% in patients who have undergone resection of liver metastases.<sup>182,185</sup> Therefore, decisions relating to patient suitability, or potential suitability, and subsequent selection for metastatic colorectal surgery are critical junctures in the management of metastatic colorectal liver disease<sup>187</sup> (discussed further in *Determining Resectability*). For patients presenting with unresectable metastases and an intact primary that is not acutely obstructed, palliative resection of the primary is rarely indicated, and systemic chemotherapy is the preferred initial maneuver.<sup>188</sup>

Evidence supporting resection of extrahepatic metastases in patients with metastatic colorectal cancer is extremely limited. In a recent

retrospective analysis of patients undergoing concurrent complete resection of hepatic and extrahepatic disease, the 5-year survival rate was lower than in patients without extrahepatic disease, and virtually all patients who underwent resection of extrahepatic metastases experienced disease recurrence.<sup>189,190</sup> However, a recent international analysis of 1629 patients with colorectal liver metastases showed that 16% of the 171 patients (10.4%) who underwent concurrent resection of extrahepatic and hepatic disease remained disease-free at a median follow-up of 26 months, suggesting that concurrent resection may be of significant benefit in well-selected patients (ie, those with smaller total number of metastases).<sup>191</sup>

Recent data suggest that a surgical approach to the treatment of recurrent hepatic disease isolated to the liver can be safely undertaken. However, in a retrospective analysis, 5-year survival was shown to decrease with each subsequent curative-intent surgery, and the presence of extrahepatic disease at the time of surgery was independently associated with a poor prognosis.<sup>192</sup> In a more recent retrospective analysis of 43 patients who underwent repeat hepatectomy for recurrent disease, 5-year OS and progression-free survival (PFS) rates were reported to be 73% and 22%, respectively.<sup>193</sup> Panel consensus is that re-resection of liver or lung metastases can be considered in carefully selected patients.<sup>194</sup>

### Liver-Directed Therapies

Although the standard of care for patients with resectable metastatic disease is surgical resection, select patients with liver-only or liver-dominant metastatic disease have liver-directed treatment options in addition to or instead of surgical resection.<sup>195</sup> The role of nonextirpative liver-directed therapies in the treatment of colorectal metastases is controversial.

### Hepatic Arterial Infusion

Placement of a hepatic arterial port or implantable pump during surgical intervention for liver resection with subsequent infusion of chemotherapy directed to the liver metastases through the hepatic artery (ie, hepatic arterial infusion [HAI]) is an option (category 2B). In a randomized study of patients who had undergone hepatic resection, administration of floxuridine with dexamethasone through HAI and intravenous 5-FU with or without LV was shown to be superior to a similar systemic chemotherapy regimen alone with respect to 2-year survival free of hepatic disease.<sup>174,196</sup> The study was not powered for long-term survival, but as a trend (not significant) was seen toward better long-term outcome in the group receiving HAI at later follow-up periods.<sup>174,197</sup> Several other clinical trials have shown significant improvement in response or time to hepatic disease progression when HAI therapy was compared with systemic chemotherapy, although most have not shown a survival benefit of HAI therapy.<sup>174</sup> However, a recent randomized trial using HAI to deliver irinotecan-loaded drug-eluting beads (DEBIRI) reported an OS benefit (22 months vs. 15 months;  $P = .031$ ).<sup>198</sup> Some of the uncertainties regarding patient selection for preoperative chemotherapy are also relevant to the application of HAI.<sup>186</sup> Limitations on the use of HAI therapy include the potential for biliary toxicity<sup>174</sup> and the requirement of specific technical expertise. Panel consensus is that HAI therapy should be considered selectively, and only at institutions with extensive experience in both the surgical and medical oncologic aspects of the procedure.

### Liver-Directed Radiation

Liver-directed radiation therapies include arterial radioembolization with yttrium-90 microspheres<sup>199-206</sup> and conformal (stereotactic) external beam radiation therapy.<sup>207</sup>

A recent prospective, randomized phase III trial of 44 patients showed that radioembolization combined with chemotherapy can lengthen time to progression in patients with liver-limited metastatic colorectal cancer following progression on initial therapy (2.1 vs. 4.5 months;  $P = .03$ ).<sup>208</sup> The effect on the primary end point of time to liver progression was more pronounced (2.1 vs. 5.5 months;  $P = .003$ ). While toxicity with radioembolization is relatively low, the data supporting its efficacy are limited to very small trials and trials with highly selected patients. Therefore, the use of arterial-directed therapies, such as radioembolization, in highly selected patients remains a category 3 recommendation based on the limited amount of evidence<sup>209</sup> and different institutional practice patterns.

External beam radiotherapy to the metastatic site can be considered in highly selected cases in which the patient has a limited number of liver or lung metastases or the patient is symptomatic (category 3 recommendation) or in the setting of a clinical trial. It should be delivered in a highly conformal manner and should not be used in place of surgical resection. The possible techniques include three-dimensional conformal radiotherapy, stereotactic body radiosurgery, and IMRT, which uses computer imaging to focus radiation to the tumor site and potentially decrease toxicity to normal tissue.<sup>168,210-213</sup>

### **Tumor Ablation**

Although resection is the standard approach for the local treatment of resectable metastatic disease, some patients who cannot undergo resection because of comorbidity, location of the metastatic lesions, or an estimate of inadequate liver volume after resection may be candidates for tumor ablation therapy.<sup>214</sup> Several retrospective studies have compared radiofrequency ablation (RFA) and liver resection in the treatment of liver metastases.<sup>215-218</sup> Most of these studies have shown RFA to be inferior to resection in terms of rates of local recurrence and

5-year OS.<sup>215,219</sup> Whether the differences in outcome observed for patients with liver metastases treated with RFA versus resection alone are from patient selection bias, technological limitations of RFA, or a combination of these factors, is currently unclear.<sup>216</sup> A 2010 ASCO clinical evidence review determined that RFA has not been well-studied in the setting of colorectal cancer liver metastases, with no randomized controlled trials having been reported.<sup>220</sup> The ASCO panel concluded that a compelling need exists for more research in this area. A 2012 Cochrane Database systematic review recently came to similar conclusions.<sup>221</sup>

Recently, a trial was reported in which 119 patients were randomized to systemic treatment or systemic treatment plus RFA with or without resection.<sup>222</sup> No difference in OS was seen, but PFS was improved at 3 years in the RFA group (27.6% vs. 10.6%; HR, 0.63; 95% CI, 0.42-0.95;  $P = .025$ ).

The panel does not consider ablation to be a substitute for resection in patients with completely resectable disease. In addition, resection or ablation (either alone or in combination with resection) should be reserved for patients with disease that is completely amenable to local therapy. Use of surgery, ablation, or the combination, with the goal of less-than-complete resection/ablation of all known sites of disease, is not recommended.

### **Peritoneal Carcinomatosis**

Approximately 17% of patients with metastatic colorectal cancer have peritoneal carcinomatosis, with 2% having the peritoneum as the only site of metastasis. The goal of treatment for most abdominal/peritoneal metastases is palliative, rather than curative, and consists of systemic therapy (See *Chemotherapy for Advanced or Metastatic Disease*) with palliative surgery or stenting if needed. Patients with peritoneal

metastases generally have a shorter PFS and OS than those without peritoneal involvement.<sup>223</sup>

Several surgical series have addressed the role of cytoreductive surgery (ie, peritoneal stripping surgery) and perioperative hyperthermic intraperitoneal chemotherapy (HIPEC) for the treatment of peritoneal carcinomatosis without extraabdominal metastases.<sup>224-228</sup> In the only randomized controlled trial of this approach, Verwaal et al<sup>229</sup> randomized 105 patients to either standard therapy (5-FU/LV with or without palliative surgery) or to aggressive cytoreductive surgery and HIPEC with mitomycin C; postoperative 5-FU/LV was given to 33 of 47 patients. OS was 12.6 months in the standard arm and 22.3 months in the HIPEC arm ( $P = .032$ ). However, treatment-related morbidity was high, and the mortality was 8% in the HIPEC group, mostly related to bowel leakage. In addition, long-term survival does not seem to be improved by this treatment as seen by follow-up results.<sup>230</sup> Importantly, this trial was performed without oxaliplatin, irinotecan, or molecularly targeted agents. Some experts have argued that the OS difference seen might have been much smaller if these agents were used (ie, the control group would have had better outcomes).<sup>231</sup>

Other criticisms of the Verwaal trial have been published.<sup>231</sup> One important point is that the trial included patients with peritoneal carcinomatosis of appendiceal origin, a group which has seen greater benefit with the cytoreductive surgery/HIPEC approach.<sup>224,227,232</sup> A retrospective multicenter cohort study reported median OS times of 30 and 77 months for patients with peritoneal carcinomatosis of colorectal origin and appendiceal origin, respectively.<sup>227</sup> The median OS time for patients with pseudomyxoma peritonei, which arises from mucinous appendiceal carcinomas, was not reached at the time of publication. A recent retrospective international registry study reported 10- and 15-year survival rates of 63% and 59%, respectively, in patients with

pseudomyxoma peritonei from mucinous appendiceal carcinomas treated with cytoreductive surgery and HIPEC, suggesting that the approach is beneficial in this population.<sup>233</sup>

The individual components of this approach have not been well studied. In fact, studies in rats have suggested that the hyperthermia component of the treatment is irrelevant.<sup>234</sup> Results of a retrospective cohort study also suggest that heat may not affect outcomes from the procedure.<sup>225</sup> In addition, significant morbidity and mortality are associated with this procedure. A 2006 meta-analysis of 2 randomized controlled trials and 12 other studies reported morbidity rates ranging from 23% to 44% and mortality rates ranging from 0% to 12%.<sup>228</sup> While the risks are reportedly decreasing with time (ie, recent studies report 1%–5% mortality rates at centers of excellence<sup>231</sup>), the benefits of the approach have not been definitively shown. Therefore, the panel currently considers the treatment of disseminated carcinomatosis with cytoreductive surgery and HIPEC to be investigational and does not endorse this therapy outside of a clinical trial. However, the panel recognizes the need for randomized clinical trials that will address the risks and benefits associated with each of these modalities.

### Determining Resectability

The consensus of the panel is that patients diagnosed with potentially resectable metastatic colorectal cancer should undergo an upfront evaluation by a multidisciplinary team, including surgical consultation (ie, with an experienced hepatic surgeon in cases involving liver metastases) to assess resectability status. The criteria for determining patient suitability for resection of metastatic disease are the likelihood of achieving complete resection of all evident disease with negative surgical margins and maintaining adequate liver reserve.<sup>235-238</sup> It should be noted that size alone is rarely a contraindication to resection of a

tumor. Resectability differs fundamentally from end points that focus more on palliative measures. Instead, the resectability end point is focused on the potential of surgery to cure the disease.<sup>239</sup> Resection should not be undertaken unless complete removal of all known tumor is realistically possible (R0 resection), because incomplete resection or debulking has not been shown to be beneficial.<sup>171,235</sup>

### Conversion to Resectability

The majority of patients diagnosed with metastatic colorectal disease have unresectable disease. However, for those with liver-limited unresectable disease that, because of involvement of critical structures, cannot be resected unless regression is accomplished, chemotherapy is being increasingly considered in highly selected cases in an attempt to downsize colorectal metastases and convert them to a resectable status. Patients presenting with large numbers of metastatic sites within the liver or lung are unlikely to achieve an R0 resection simply on the basis of a favorable response to chemotherapy, as the probability of complete eradication of a metastatic deposit by chemotherapy alone is low. These patients should be regarded as having unresectable disease not amenable to conversion therapy. In some highly selected cases, however, patients with significant response to conversion chemotherapy can be converted from unresectable to resectable status.<sup>219</sup>

Any active metastatic chemotherapeutic regimen can be used in an attempt to convert an unresectable patient to a resectable status, because the goal is not specifically the eradication of micrometastatic disease, but rather the obtaining of optimal size regression of the visible metastases. An important point to keep in mind is that irinotecan- and oxaliplatin-based chemotherapeutic regimens may cause liver steatohepatitis and sinusoidal liver injury, respectively.<sup>240-244</sup> To limit the development of hepatotoxicity, it is therefore recommended that surgery

be performed as soon as possible after the patient becomes resectable. Some of the trials addressing various conversion therapy regimens are discussed below.

In the study of Pozzo et al, it was reported that chemotherapy with irinotecan combined with 5-FU/LV enabled a significant portion (32.5%) of the patients with initially unresectable liver metastases to undergo liver resection.<sup>237</sup> The median time to progression was 14.3 months, with all of these patients alive at a median follow-up of 19 months. In a phase II study conducted by the NCCTG,<sup>172</sup> 42 patients with unresectable liver metastases were treated with FOLFOX. Twenty-five patients (60%) had tumor reduction and 17 patients (40%; 68% of the responders) were able to undergo resection after a median period of 6 months of chemotherapy. In another study, 1104 initially unresectable patients with colorectal liver disease were treated with chemotherapy, which included oxaliplatin in the majority of cases, and 138 patients (12.5%) classified as “good responders” underwent secondary hepatic resection.<sup>181</sup> The 5-year DFS rate for these 138 patients was 22%. In addition, results from a retrospective analysis of 795 previously untreated patients with metastatic colorectal cancer enrolled in the Intergroup N9741 randomized phase III trial evaluating the efficacy of mostly oxaliplatin-containing chemotherapy regimens indicated that 24 patients (3.3%; 2 of the 24 had lung lung metastases) were able to undergo curative resection after treatment.<sup>245</sup> The median OS time in this group was 42.4 months.

In addition, FOLFOXIRI (infusional 5-FU, LV, oxaliplatin, irinotecan) has been compared with FOLFIRI in 2 randomized clinical trials in unresectable patients.<sup>246,247</sup> In both studies, FOLFOXIRI led to an increase in R0 secondary resection rates: 6% versus 15%,  $P = .033$  in the Gruppo Oncologico Nord Ovest (GONO) trial<sup>246</sup>; and 4% versus 10%,  $P = .08$  in the Gastrointestinal Committee of the Hellenic

Oncology Research Group (HORG) trial.<sup>247</sup> In a follow-up study of the GONO trial, the 5-year survival rate was higher in the group receiving FOLFOXIRI (15% vs. 8%), with a median OS of 23.4 versus 16.7 months ( $P = .026$ ).<sup>248</sup>

More recent favorable results of randomized clinical trials evaluating FOLFIRI or FOLFOX for the purpose of conversion of unresectable disease to resectable disease in combination with anti-epidermal growth factor receptor (EGFR) inhibitors have been reported.<sup>249,250</sup> For instance, in the CELIM phase II trial, patients were randomized to receive cetuximab with either FOLFOX6 or FOLFIRI.<sup>249</sup> Retrospective analysis showed that in both treatment arms combined resectability increased from 32% to 60% after chemotherapy in patients with wild-type *KRAS* ( $P < .0001$ ) with the addition of cetuximab. A recent meta-analysis of 4 randomized controlled trials concluded that the addition of cetuximab or panitumumab to chemotherapy significantly increased the response rate, the R0 resection rate (from 11% to 18%; RR 1.59;  $P = .04$ ), and PFS, but not OS in patients with wild-type *KRAS*-containing tumors.<sup>251</sup>

The role of bevacizumab in the unresectable patient, whose disease is felt to be potentially convertible to resectability with a reduction in tumor size, has also been studied. Data seem to suggest that bevacizumab modestly improves the response rate to irinotecan-based regimens,<sup>252,253</sup> and so when an irinotecan-based regimen is selected for an attempt to convert unresectable disease to resectability, the use of bevacizumab would seem an appropriate consideration. On the other hand, a 1400-patient randomized, double-blind, placebo-controlled trial of CapeOx or FOLFOX with or without bevacizumab showed absolutely no benefit in terms of response rate or tumor regression for the addition of bevacizumab, as measured by both investigators and an independent radiology review committee.<sup>254</sup> Therefore, arguments for use of bevacizumab with oxaliplatin-based therapy in this “convert to

resectability” setting are not compelling. However, because it is not known in advance whether resectability will be achieved, the use of bevacizumab with oxaliplatin-based therapy in this setting is acceptable.

When chemotherapy is planned for patients with initially unresectable disease, the panel recommends that a surgical re-evaluation be planned 2 months after initiation of chemotherapy, and that those patients who continue to receive chemotherapy undergo surgical re-evaluation every 2 months thereafter.<sup>244,255-257</sup> Reported risks associated with chemotherapy include the potential for development of liver steatosis or steatohepatitis when oxaliplatin or irinotecan-containing chemotherapeutic regimens are administered.<sup>240</sup> To limit the development of hepatotoxicity, it is therefore recommended that surgery be performed as soon as possible after the patient becomes resectable.

### Neoadjuvant and Adjuvant Therapy for Resectable Metastatic Disease

The panel recommends that a course of an active systemic chemotherapy regimen for metastatic disease, administered for a total perioperative treatment time of approximately 6 months, be considered for most patients undergoing liver or lung resection to increase the likelihood that residual microscopic disease will be eradicated. A recent meta-analysis identified 3 randomized clinical trials comparing surgery alone to surgery plus systemic therapy with 642 evaluable patients with colorectal liver metastases.<sup>258</sup> The pooled analysis showed a benefit of chemotherapy in PFS (pooled HR, 0.75; CI, 0.62-0.91;  $P = .003$ ) and DFS (pooled HR, 0.71; CI, 0.58-0.88;  $P = .001$ ), but not in OS (pooled HR, 0.74; CI, 0.53-1.05;  $P = .088$ ).

The choice of chemotherapy regimen in the pre- and postoperative settings depends on several factors, including the chemotherapy history of the patient and the response rates and safety/toxicity issues

associated with the regimens. Regimens recommended for adjuvant therapy and neoadjuvant therapy are the same (see the next section). However, if the tumor grows on neoadjuvant treatment, an active regimen for advanced disease or observation is recommended.

The optimal sequencing of chemotherapy remains unclear. Patients with resectable disease may undergo liver resection first, followed by postoperative adjuvant chemotherapy. Alternatively, perioperative (neoadjuvant plus postoperative) chemotherapy can be used.<sup>259</sup>

Potential advantages of preoperative chemotherapy include: earlier treatment of micrometastatic disease, determination of responsiveness to chemotherapy (which can be prognostic and help in planning postoperative therapy), and avoidance of local therapy for those patients with early disease progression. Potential disadvantages include missing the “window of opportunity” for resection because of the possibility of disease progression or achievement of a complete response, thereby making it difficult to identify areas for resection.<sup>174,260,261</sup> In fact, results from a recent study of patients with colorectal cancer receiving preoperative chemotherapy indicated that viable cancer was still present in most of the original sites of metastases when these sites were examined pathologically despite achievement of a complete response as evaluated on CT scan.<sup>261,262</sup> Therefore, during treatment with preoperative chemotherapy, frequent evaluations must be undertaken and close communication must be maintained among medical oncologists, radiologists, surgeons, and patients so that a treatment strategy can be developed that optimizes exposure to the preoperative chemotherapy regimen and facilitates an appropriately timed surgical intervention.<sup>240</sup>

Other reported risks associated with the preoperative chemotherapy approach include the potential for development of liver steatohepatitis

and sinusoidal liver injury when irinotecan- and oxaliplatin-based chemotherapeutic regimens are administered, respectively.<sup>240-244</sup> To reduce the development of hepatotoxicity, the neoadjuvant period is usually limited to 2 to 3 months, and patients should be carefully monitored by a multidisciplinary team.

### Chemotherapy for Advanced or Metastatic Disease

The current management of disseminated metastatic colon cancer involves various active drugs, either in combination or as single agents: 5-FU/LV, capecitabine, irinotecan, oxaliplatin, bevacizumab, cetuximab, panitumumab, ziv-aflibercept, and regorafenib.<sup>110,154,246,247,263-299</sup> The putative mechanisms of action of these agents are varied and include interference with DNA replication and inhibition of the activities of vascular endothelial growth factor (VEGF) and epidermal growth factor (EGF) receptors.<sup>300-303</sup> The choice of therapy is based on consideration of the goals of therapy, the type and timing of prior therapy, and the differing toxicity profiles of the constituent drugs. Although the specific chemotherapy regimens listed in the guideline are designated according to whether they pertain to initial therapy, therapy after first progression, or therapy after second progression, it is important to clarify that these recommendations represent a continuum of care and that these lines of treatment are blurred rather than discrete.<sup>279</sup> For example, if oxaliplatin is administered as a part of an initial treatment regimen but is discontinued after 12 weeks or earlier for escalating neurotoxicity, continuation of the remainder of the treatment regimen would still be considered initial therapy.

Principles to consider at the start of therapy include preplanned strategies for altering therapy for patients exhibiting a tumor response or disease characterized as stable or progressive, and plans for adjusting therapy for patients who experience certain toxicities. For example,

decisions related to therapeutic choices after first progression of disease should be based partly on the prior therapies received (ie, exposing the patient to a range of cytotoxic agents). Furthermore, an evaluation of the efficacy and safety of these regimens for an individual patient must take into account not only the component drugs, but also the doses, schedules, and methods of administration of these agents, and the potential for surgical cure and the performance status of the patient.

As initial therapy for metastatic disease in a patient appropriate for intensive therapy (ie, one with a good tolerance for this therapy for whom a high tumor response rate would be potentially beneficial), the panel recommends a choice of 5 chemotherapy regimens: FOLFOX (ie, mFOLFOX6),<sup>287,304</sup> FOLFIRI,<sup>110</sup> CapeOx,<sup>266,305,306</sup> infusional 5-FU/LV or capecitabine,<sup>110,154,289,299</sup> or FOLFOXIRI (infusional 5-FU/LV, oxaliplatin, and irinotecan).<sup>246,247</sup>

Few studies have addressed the sequencing of therapies in advanced metastatic disease. Prior to the use of targeted agents, 3 studies randomized patients to different schedules.<sup>307-309</sup> The data from these trials suggest that there is little difference in clinical outcomes if intensive therapy is given in first line or if less intensive therapy is given first followed by more intensive combinations.

A study of 6286 patients from 9 trials that evaluated the benefits and risks associated with intensive first-line treatment in the setting of metastatic colorectal cancer treatment according to patient performance status showed similar therapeutic efficacy for patients with performance status of 2 or 1 or less as compared with control groups, although the risks of certain gastrointestinal toxicities were significantly increased for patients with a performance status of 2.<sup>310</sup>

Although use of FOLFOXIRI as initial therapy is a category 2B recommendation, the panel does not consider one of the other regimens (ie, FOLFOX, CapeOx, FOLFIRI, 5-FU/LV, capecitabine) to be preferable over the others as initial therapy for metastatic disease. Biologic agents used as part of initial therapy can include bevacizumab, cetuximab, or panitumumab.

### **Regimens Not Recommended**

The consensus of the panel is that infusional 5-FU regimens seem to be less toxic than bolus regimens and that any bolus regimen of 5-FU is inappropriate when administered with either irinotecan or oxaliplatin. Therefore, the panel no longer recommends using the IFL (irinotecan, bolus 5-FU/LV) regimen (which was shown to be associated with increased mortality and decreased efficacy relative to FOLFIRI in the BICC-C trial<sup>252,311</sup> and inferior to FOLFOX in the Intergroup trial<sup>312</sup>) at any point in the therapy continuum. 5-FU in combination with irinotecan or oxaliplatin should be administered via an infusional biweekly regimen,<sup>110</sup> or capecitabine can be used with oxaliplatin.<sup>297</sup>

The Dutch CAIRO trial showed promising results for the use of capecitabine/irinotecan (CapelRI) in the first-line treatment of metastatic colorectal cancer.<sup>308</sup> However, in the American BICC-C trial, CapelRI showed worse PFS than FOLFIRI (5.8 vs. 7.6 months;  $P = .015$ ), and was considerably more toxic with higher rates of severe vomiting, diarrhea, and dehydration.<sup>252</sup> In this trial, the CapelRI arm was discontinued. The EORTC study 40015 also compared FOLFIRI with CapelRI and was discontinued after enrollment of only 85 patients because 7 deaths were determined to be treatment-related (5 in the CapelRI arm).<sup>313</sup> Several European studies have assessed the safety and efficacy of CapelRI in combination with bevacizumab (CapelRI/Bev) in the first-line metastatic setting. A small Spanish study of 46 patients who received CapelRI/Bev showed encouraging results

with good tolerability.<sup>314</sup> Preliminary results from a randomized phase II study conducted in France were presented in 2009, showing a manageable toxicity profile for CapelRI/Bev in this setting.<sup>315</sup> Finally, a randomized phase III HeCOG trial compared CapelRI/Bev and FOLFIRI/Bev in the first-line metastatic setting and found no significant differences in efficacy between the regimens.<sup>316</sup> Despite the differing toxicity profiles reported, the toxicities seemed to be reasonable in both arms. Because of the concerns about the toxicity of the CapelRI combination, which may differ between American and European patients, the panel does not recommend CapelRI or CapelRI/Bev for the first-line treatment of metastatic colorectal cancer.

### **Leucovorin Shortage**

A shortage of leucovorin currently exists in the United States (see the discussion in the section above on *Adjuvant Chemotherapy for Resectable Colon Cancer* for a detailed discussion).

### **FOLFOX**

A recent EORTC phase III study (EORTC 40983) evaluating use of perioperative FOLFOX (6 cycles before and 6 cycles after surgery) for patients with resectable liver metastases showed absolute improvements in 3-year PFS of 8.1% ( $P = .041$ ) and 9.2% ( $P = .025$ ) for all eligible patients and all resected patients, respectively, when chemotherapy in conjunction with surgery was compared with surgery alone.<sup>317</sup> The partial response rate after preoperative FOLFOX was 40%, and operative mortality was less than 1% in both treatment groups. However, no difference in OS was seen between the groups, perhaps because second-line therapy was given to 77% of the patients in the surgery only arm and 59% of the patients in the chemotherapy arm.<sup>318</sup>

Use of oxaliplatin has been associated with an increased incidence of peripheral sensory neuropathy.<sup>319</sup> Results of the OPTIMOX1 study showed that a “stop-and-go” approach using oxaliplatin-free intervals resulted in decreased neurotoxicity but did not affect OS in patients receiving FOLFOX as initial therapy for metastatic disease.<sup>320</sup> Therefore, the panel recommends adjusting the schedule/timing of the administration of this drug as a means of limiting this adverse effect. Discontinuation of oxaliplatin from FOLFOX or CapeOx should be strongly considered after 3 months of therapy, or sooner for unacceptable neurotoxicity, with other drugs in the regimen maintained for the entire 6 months or until time of tumor progression. Patients experiencing neurotoxicity on oxaliplatin should not receive subsequent oxaliplatin therapy until and unless they experience near-total resolution of that neurotoxicity. Data are insufficient supporting the routine use of calcium/magnesium infusion to prevent oxaliplatin-related neurotoxicity.<sup>321-328</sup>

In the phase II OPTIMOX2 trial, patients were randomized to receive either an OPTIMOX1 approach (discontinuation of oxaliplatin after 6 cycles of FOLFOX to prevent or reduce neurotoxicity with continuance of 5-FU/LV followed by reintroduction of oxaliplatin on disease progression) or an induction FOLFOX regimen (6 cycles) followed by discontinuation of all chemotherapy until tumor progression reached baseline, followed by reintroduction of FOLFOX.<sup>329</sup> Results of the study showed no difference in OS for patients receiving the OPTIMOX1 approach compared with those undergoing an early, pre-planned, chemotherapy-free interval (median OS 23.8 vs. 19.5 months;  $P = .42$ ). However, the median duration of disease control, which was the primary end point of the study, reached statistical significance at 13.1 months in patients undergoing maintenance therapy and 9.2 months in patients with a chemotherapy-free interval ( $P = .046$ ).<sup>329</sup>

The addition of bevacizumab is an option when FOLFOX is chosen as initial therapy,<sup>254,330</sup> as is the addition of panitumumab for patients with disease characterized by the wild-type *KRAS* gene (see discussions on *Bevacizumab, Cetuximab, and Panitumumab*, and *The Role of KRAS and BRAF Status*, below).<sup>275,331</sup> With respect to the treatment of metastatic disease with bevacizumab-containing regimens or chemotherapy without an additional biologic agent, panel consensus is that FOLFOX and CapeOx can be used interchangeably.

### CapeOx

The combination of capecitabine and oxaliplatin, known as CapeOx or XELOX, has been studied as an active first-line therapy for patients with metastatic colorectal cancer.<sup>266,305,306,332,333</sup> In a randomized phase III trial comparing CapeOx and FOLFOX in 2034 patients, the regimens showed similar median PFS intervals of 8.0 and 8.5 months, respectively, and CapeOx was determined to be noninferior to FOLFOX as first-line treatment of metastatic disease.<sup>266</sup> A recent meta-analysis of 3603 patients from 7 randomized controlled trials also showed that CapeOx and FOLFOX had similar benefits for patients with metastatic colorectal cancer.<sup>334</sup>

Use of oxaliplatin has been associated with an increased incidence of peripheral sensory neuropathy (see *FOLFOX*, above).<sup>335</sup> Discontinuation of oxaliplatin from FOLFOX or CapeOx should be strongly considered after 3 months of therapy (the OPTIMOX1 approach<sup>320</sup>), or sooner for unacceptable neurotoxicity, with other drugs in the regimen maintained until tumor progression. Patients experiencing neurotoxicity on oxaliplatin should not receive subsequent oxaliplatin therapy until and unless they experience near-total resolution of that neurotoxicity. Data are insufficient to support the routine use of calcium/magnesium infusion to prevent oxaliplatin-related neurotoxicity.<sup>321-326</sup>

Regarding the toxicities associated with capecitabine use, the panel noted that: 1) that patients with diminished creatinine clearance may accumulate levels of the drug, and therefore may require dose modification;<sup>336</sup> 2) the incidence of hand-foot syndrome was increased for patients receiving capecitabine-containing regimens versus either bolus or infusional regimens of 5-FU/LV;<sup>330,336</sup> and 3) North American patients may experience a higher incidence of adverse events with certain doses of capecitabine compared with patients from other countries.<sup>337</sup> These toxicities may necessitate modifications in the dosing of capecitabine,<sup>330,336,338</sup> and patients on capecitabine should be monitored closely so that dose adjustments can be made at the earliest signs of certain side effects, such as hand-foot syndrome.

The addition of bevacizumab is an option if CapeOx is chosen as initial therapy.<sup>254,330</sup> With respect to the treatment of metastatic disease with bevacizumab-containing regimens or chemotherapy without an additional biologic agent, the consensus of the panel is that FOLFOX and CapeOx can be used interchangeably.

### FOLFIRI

Evidence for the comparable efficacy for FOLFOX and FOLFIRI comes from a crossover study in which patients received either FOLFOX or FOLFIRI as initial therapy and were then switched to the other regimen at disease progression.<sup>304</sup> Similar response rates and PFS times were obtained when these regimens were used as first-line therapy. Further support for this conclusion has come from results of a phase III trial comparing the efficacy and toxicity of FOLFOX and FOLFIRI regimens in previously untreated patients with metastatic colorectal cancer.<sup>268</sup> No differences were observed in response rate, PFS times, and OS between the treatment arms.

Toxicities associated with irinotecan include both early and late forms of diarrhea, dehydration, and severe neutropenia.<sup>339,340</sup> Irinotecan is inactivated by the enzyme uridine diphosphate glucuronosyltransferase 1A1 (UGT1A1), which is also involved in converting substrates such as bilirubin into more soluble forms through conjugation with certain glycosyl groups. Deficiencies in UGT1A1 can be caused by certain genetic polymorphisms and can result in conditions associated with accumulation of unconjugated hyperbilirubinemias, such as types I and II of the Crigler-Najjar and Gilbert syndromes. Thus, irinotecan should be used with caution and at a decreased dose in patients with Gilbert syndrome or elevated serum bilirubin. Similarly, certain genetic polymorphisms in the gene encoding for UGT1A1 can result in a decreased level of glucuronidation of the active metabolite of irinotecan, resulting in an accumulation of the drug,<sup>340-342</sup> although severe irinotecan-related toxicity is not experienced by all patients with these polymorphisms.<sup>342</sup> Commercial tests are available to detect the UGT1A1\*28 allele, which is associated with decreased gene expression and, hence, reduced levels of UGT1A1 expression.<sup>341,343</sup> Also, a warning has been added to the label for Camptosar indicating that a reduced starting dose of the drug should be used in patients known to be homozygous for UGT1A1\*28.<sup>339</sup> A practical approach to the use of UGT1A1\*28 allele testing with respect to patients receiving irinotecan has been presented,<sup>342</sup> although guidelines for use of this test in clinical practice have not been established. Furthermore, UGT1A1 testing on patients who experience irinotecan toxicity is not recommended, because they will require a dose reduction regardless of the UGT1A1 test result.

Results from a recent phase IV trial in 209 patients with metastatic colorectal cancer who received bevacizumab in combination with FOLFIRI as first-line therapy showed that this combination was as

effective and well-tolerated as bevacizumab with other 5-FU-based therapies.<sup>344</sup> Therefore, the addition of bevacizumab to FOLFIRI is recommended as an option for initial therapy; alternatively, cetuximab or panitumumab (only for tumors characterized by wild-type *KRAS*) can be added to this regimen.<sup>275,286,288,295,345</sup>

### **Infusional 5-FU/LV and Capecitabine**

For patients with impaired tolerance to aggressive initial therapy, the guidelines recommend infusional 5-FU/LV or capecitabine with or without bevacizumab as an option.<sup>110,283,284,294,297,330</sup> Patients with metastatic cancer with no improvement in functional status after this less intensive initial therapy should receive best supportive care. Patients showing improvement in functional status should be treated with one of the options specified for initial therapy for advanced or metastatic disease. Toxicities associated with capecitabine use are discussed earlier (see CapeOx).

In a pooled analysis of results from 2 randomized clinical trials involving patients with a potentially curative resection of liver or lung metastases randomly assigned to either postoperative systemic chemotherapy with 5-FU/LV or observation alone after surgery, the median PFS was 27.9 months in the chemotherapy arm and 18.8 months for those undergoing surgery alone (HR, 1.32; 95% CI, 1.00-1.76;  $P = .058$ ), with no significant difference in OS.<sup>346</sup>

### **FOLFOXIRI**

FOLFOXIRI is also listed as an option for initial therapy in patients with unresectable metastatic disease (category 2B).<sup>246,247</sup> If FOLFOXIRI is used, the panel recommends that it be without the addition of a biologic agent, because data regarding the efficacy and safety of such combinations are not yet mature.

Use of FOLFOXIRI compared with FOLFIRI as initial therapy for the treatment of metastatic disease has been investigated in 2 randomized phase III trials.<sup>246,247</sup> In the GONO study, statistically significant improvements in PFS (9.8 vs. 6.9 months; HR, 0.63;  $P = .0006$ ) and median OS (22.6 vs. 16.7 months; HR, 0.70;  $P = .032$ ) were observed in the FOLFOXIRI arm,<sup>246</sup> although no OS difference was seen between treatment arms in the HORG study (median OS, 19.5 and 21.5 months, for FOLFIRI and FOLFOXIRI, respectively;  $P = .337$ ).<sup>247</sup> Both studies showed some increased toxicity in the FOLFOXIRI arm (eg, significant increases in neurotoxicity and neutropenia,<sup>246</sup> diarrhea, alopecia, and neurotoxicity<sup>247</sup>), but no differences in the rate of toxic death were reported in either study. Long-term outcomes of the GONO trial with a median follow-up of 60.6 months were recently reported.<sup>248</sup> The improvements in PFS and OS were maintained.

### Bevacizumab

Bevacizumab<sup>347</sup> is a humanized monoclonal antibody that blocks the activity of VEGF, a factor that plays an important role in tumor angiogenesis. Pooled results from several randomized phase II studies have shown that the addition of bevacizumab to first-line 5-FU/LV improved OS in patients with unresectable metastatic colorectal cancer compared with those receiving these regimens without bevacizumab.<sup>253,348,349</sup> A combined analysis of the results of these trials showed that the addition of bevacizumab to 5-FU/LV was associated with a median survival of 17.9 versus 14.6 months for regimens consisting of 5-FU/LV or 5-FU/LV plus irinotecan without bevacizumab ( $P = .008$ ).<sup>284</sup> A study of previously untreated patients receiving bevacizumab plus 5-FU/irinotecan (IFL) also provided support for the inclusion of bevacizumab in initial therapy.<sup>253</sup> In that pivotal trial, a longer survival time was observed with the use of bevacizumab (20.3 vs. 15.6 months; HR, 0.66;  $P < .001$ ).

Results have also been reported from a recent large, head-to-head, randomized, double-blind, placebo-controlled, phase III study (NO16966) in which CapeOx (capecitabine dose, 1000 mg/m<sup>2</sup>, twice daily for 14 days) with bevacizumab or placebo was compared with FOLFOX with bevacizumab or placebo in 1400 patients with unresectable metastatic disease.<sup>254</sup> The addition of bevacizumab to oxaliplatin-based regimens was associated with a more modest increase of 1.4 months in PFS compared with these regimens without bevacizumab (HR, 0.83; 97.5% CI, 0.72-0.95;  $P = .0023$ ), and the difference in OS, which was also a modest 1.4 months, did not reach statistical significance (HR, 0.89; 97.5% CI, 0.76-1.03;  $P = .077$ ).<sup>254</sup> Researchers have suggested that differences observed in cross-study comparisons of NO16966 with other trials might be related to differences in the discontinuation rates and durations of treatment between trials, although these hypotheses are conjectural.<sup>292</sup> However, in this 1400-patient randomized study, absolutely no difference in response rate was seen with and without bevacizumab (see later discussion), and this finding would not have been potentially influenced by the early withdrawal rates, which would have occurred after the responses would have occurred. Results of subset analyses evaluating the benefit of adding bevacizumab to either FOLFOX or CapeOx indicated that bevacizumab was associated with improvements in PFS when added to CapeOx but not FOLFOX.<sup>254</sup> The randomized phase III trial HEPATICA, which is comparing CapeOx with and without bevacizumab as adjuvant therapy in patients with liver metastases, is currently recruiting patients (ClinicalTrials.gov identifier: NCT00394992).<sup>350</sup>

Several meta-analyses have shown a benefit for the use of bevacizumab in first-line therapy for metastatic colorectal cancer.<sup>351-353</sup> A recent meta-analysis of 6 randomized clinical trials (3060 patients) that

assessed the efficacy of bevacizumab in first-line treatment of metastatic colorectal cancer found that bevacizumab gave a PFS (HR, 0.72; 95% CI, 0.66-0.78;  $P < .00001$ ) and OS (HR, 0.84; 95% CI, 0.77-0.91;  $P < .00001$ ) advantage.<sup>354</sup> However, subgroup analyses showed that the advantage was limited to irinotecan-based regimens. In addition, a recent analysis of the SEER-Medicare database found that bevacizumab added a modest improvement to OS of patients with stage IV colorectal cancer diagnosed between 2002 and 2007 (HR, 0.85; 95% CI, 0.78-0.93).<sup>355</sup> The survival advantage was not evident when bevacizumab was combined with oxaliplatin-based chemotherapy, but was evident in irinotecan-based regimens. Limitations of this analysis have been discussed,<sup>356</sup> but, overall, the addition of bevacizumab to first-line chemotherapy appears to offer a modest clinical benefit.

No data directly address whether bevacizumab should be used with chemotherapy in the perioperative treatment of resectable metastatic disease. Recent data regarding the lack of efficacy of bevacizumab in the adjuvant setting in stage II and III colon cancer<sup>159,165</sup> have prompted some to reconsider the role of bevacizumab in the adjuvant setting of resectable colorectal metastases. The panel does not recommend the use of bevacizumab in the post-resection stage IV adjuvant setting, unless a response to bevacizumab was seen in the neoadjuvant setting.

The risk of stroke and other arterial events is increased in patients receiving bevacizumab, especially in those aged 65 years or older. In addition, gastrointestinal perforation is a rare but important side effect of bevacizumab therapy in patients with colorectal cancer.<sup>330,357</sup> Extensive prior intra-abdominal surgery, such as peritoneal stripping, may predispose patients to gastrointestinal perforation. A small cohort of patients with advanced ovarian cancer had an unacceptably high rate of gastrointestinal perforation when treated with bevacizumab.<sup>358</sup> This result illustrated that peritoneal debulking surgery may be a risk factor

for gastrointestinal perforation, whereas the presence of an intact primary tumor does not seem to increase the risk for gastrointestinal perforation. A recent meta-analysis of randomized controlled trials showed that the addition of bevacizumab to chemotherapy is associated with a higher incidence of treatment-related mortality than chemotherapy alone (relative risk, 1.33; 95% CI, 1.02-1.73;  $P = .04$ ), with hemorrhage (23.5%), neutropenia (12.2%), and gastrointestinal perforation (7.1%) being the most common causes of fatality.<sup>359</sup> Venous thromboembolisms, on the other hand, were not increased in patients receiving bevacizumab with chemotherapy versus those receiving chemotherapy alone.<sup>360</sup>

Use of bevacizumab may interfere with wound healing.<sup>330,347,357</sup> A retrospective evaluation of data from 2 randomized trials of 1132 patients undergoing chemotherapy with or without bevacizumab as initial therapy for metastatic colorectal cancer indicated that the incidence of wound healing complications was increased for the group of patients undergoing a major surgical procedure while receiving a bevacizumab-containing regimen compared with the group receiving chemotherapy alone while undergoing major surgery (13% vs. 3.4%, respectively;  $P = .28$ ).<sup>357</sup> However, when chemotherapy plus bevacizumab or chemotherapy alone was administered before surgery, with a delay between bevacizumab administration and surgery of at least 6 weeks, the incidence of wound healing complications in either group of patients was low (1.3% vs. 0.5%;  $P = .63$ ). Similarly, results of a single center, nonrandomized phase II trial of patients with potentially resectable liver metastases showed no increase in bleeding or wound complications when the bevacizumab component of CapeOx plus bevacizumab therapy was stopped 5 weeks before surgery (ie, bevacizumab excluded from the sixth cycle of therapy).<sup>361</sup> In addition, no significant differences in bleeding, wound, or hepatic complications

were seen in a retrospective trial evaluating the effects of preoperative bevacizumab stopped at 8 weeks or less versus at more than 8 weeks before resection of liver colorectal metastases in patients receiving oxaliplatin- or irinotecan-containing regimens.<sup>362</sup> The panel recommends an interval of at least 6 weeks (which corresponds to 2 half-lives of the drug<sup>347</sup>) between the last dose of bevacizumab and elective surgery.

Preclinical studies suggested that cessation of anti-VEGF therapy might be associated with accelerated recurrence, more aggressive tumors on recurrence, and increased mortality. A recent retrospective meta-analysis of 5 placebo-controlled, randomized phase III trials including 4205 patients with metastatic colorectal, breast, renal, or pancreatic cancer found no difference in time to disease progression and mortality with discontinuation of bevacizumab versus discontinuation of placebo.<sup>363</sup> Although this meta-analysis has been criticized,<sup>364,365</sup> the results are supported by recent results from the NSABP Protocol C-08 trial.<sup>165</sup> This trial included patients with stage II and stage III colorectal cancer, and no differences in recurrence, mortality, or mortality 2 years after recurrence were seen between patients receiving bevacizumab versus patients in the control arm. These results suggest that no “rebound effect” is associated with bevacizumab use.

Results from 2 randomized phase III trials have shown that combination therapy with more than one biologic agent is not associated with improved outcomes and can cause increased toxicity.<sup>366,367</sup> In the PACCE trial, the addition of panitumumab to a regimen containing oxaliplatin- or irinotecan-based chemotherapy plus bevacizumab was associated with significantly shorter PFS and higher toxicity in both *KRAS* wild-type and mutant gene groups.<sup>366</sup> Similar results were observed in the CAIRO2 trial with the addition of cetuximab to a regimen containing capecitabine, oxaliplatin, and bevacizumab.<sup>367</sup> Therefore, the panel strongly recommends against the use of therapy

involving the concurrent combination of an anti-EGFR agent (cetuximab or panitumumab) and an anti-VEGF agent (bevacizumab).

### **Cetuximab and Panitumumab**

Cetuximab and panitumumab are monoclonal antibodies directed against EGFR that inhibit its downstream signaling pathways. Panitumumab is a fully human monoclonal antibody, whereas cetuximab is a chimeric monoclonal antibody.<sup>368,369</sup> Cetuximab and panitumumab have been studied in combination with FOLFIRI<sup>286,295</sup> and FOLFOX<sup>275,331</sup> as initial therapy options for treatment of metastatic colorectal cancer. A recent meta-analysis of 14 randomized controlled trials concluded that there is a clear benefit to the use of EGFR inhibitors in patients with *KRAS*-wild-type metastatic colorectal cancer.<sup>370</sup> Individual trials are discussed below.

A sizable body of recent literature has shown that tumors with a mutation in codon 12 or 13 of the *KRAS* gene are essentially insensitive to EGFR inhibitors, such as cetuximab or panitumumab (see *The Role of KRAS and BRAF Status*, below).<sup>263,295,331,371-376</sup> The panel therefore strongly recommends *KRAS* genotyping of tumor tissue (either primary tumor or metastasis) in all patients with metastatic colorectal cancer. Patients with known codon 12 or 13 *KRAS* mutations should not be treated with either cetuximab or panitumumab, either alone or in combination with other anticancer agents, because they have virtually no chance of benefit and the exposure to toxicity and expense cannot be justified. It is implied throughout the guidelines that NCCN recommendations involving cetuximab or panitumumab relate only to patients with disease characterized by the *KRAS* wild-type gene. Although *BRAF* genotyping can be considered for patients with tumors characterized by the wild-type *KRAS* gene, this testing is currently optional and not a necessary part of decision-making regarding use of anti-EGFR agents (see *KRAS* and *BRAF* testing, below).

Administration of either cetuximab or panitumumab has been associated with severe infusion reactions, including anaphylaxis, in 3% and 1% of patients, respectively.<sup>368,369</sup> Based on case reports and a small trial, administration of panitumumab seems to be feasible for patients experiencing severe infusion reactions to cetuximab.<sup>377-379</sup> Skin toxicity is a side effect of both of these agents and is *not* considered part of the infusion reactions. The incidence and severity of skin reactions with cetuximab and panitumumab seems to be very similar. Furthermore, the presence and severity of skin rash in patients receiving either of these drugs have been shown to predict increased response and survival.<sup>295,375,380-383</sup> A recent NCCN task force addressed the management of dermatologic and other toxicities associated with anti-EGFR inhibitors.<sup>384</sup> Cetuximab and panitumumab have also been associated with a risk for venous thromboembolic events.<sup>385</sup>

Based on the results of the PACCE and CAIRO2 trials, the panel strongly advises against the concurrent use of bevacizumab with either cetuximab or panitumumab (see *Bevacizumab*, above).<sup>366,367</sup> A recent editorial summarizes trials that assessed EGFR inhibitors in combination with various chemotherapy agents.<sup>386</sup> These data are also discussed here. The consensus of the panel is that cetuximab and panitumumab are not necessarily interchangeable because they have never been compared head-to-head and may have different interactions with chemotherapy regimens. The panel separately assessed the data pertaining to each antibody when making its recommendations.

### **Cetuximab with FOLFIRI**

Use of cetuximab as initial therapy for metastatic disease was investigated in the CRYSTAL trial, in which patients were randomly assigned to receive FOLFIRI with or without cetuximab.<sup>295</sup> Retrospective analyses of the subset of patients with known *KRAS* tumor status showed a statistically significant improvement in median PFS with the

addition of cetuximab in the group with disease characterized by the *KRAS* wild-type gene (9.9 vs. 8.7 months; HR, 0.68; 95% CI, 0.50-0.94;  $P = .02$ ).<sup>295</sup> The statistically significant benefit in PFS for patients with *KRAS* wild-type tumors receiving cetuximab was confirmed in a recent publication of an updated analysis of the CRYSTAL data.<sup>387</sup> This recent study included a retrospective analysis of OS in the *KRAS* wild-type population and found an improvement with the addition of cetuximab (23.5 vs. 20.0 months,  $P = .0093$ ).

### **Panitumumab with FOLFIRI**

FOLFIRI with panitumumab is listed as an option for first-line therapy in metastatic colorectal cancer based on extrapolation from data in second-line treatment.<sup>288,388-390</sup>

### **Cetuximab with FOLFOX**

Three trials have assessed the combination of FOLFOX and cetuximab in first-line treatment of metastatic colorectal cancer. In a retrospective evaluation of the subset of patients with known tumor *KRAS* status enrolled in the randomized phase II OPUS trial, addition of cetuximab to FOLFOX was associated with an increased objective response rate (61% vs. 37%; odds ratio, 2.54;  $P = .011$ ) and a very slightly lower risk of disease progression (7.7 vs. 7.2 months [a 15-day difference]; HR, 0.57; 95% CI, 0.358-0.907;  $P = .0163$ ) compared with FOLFOX alone in the subset of patients with *KRAS* wild-type tumors.<sup>331</sup> Although data supporting the statistically significant benefits in objective response rate and PFS for patients with tumors characterized by the *KRAS* wild-type gene were upheld in a recent update of this study,<sup>391</sup> no median OS benefit was observed for the addition of cetuximab to chemotherapy (22.8 months in the cetuximab arm vs. 18.5 months in the arm undergoing chemotherapy alone; HR, 0.85;  $P = .39$ ).<sup>391</sup>

Furthermore, in the recent randomized phase III Medical Research Council (MRC) COIN trial, no benefit in OS (17.9 vs. 17.0 months;  $P = .067$ ) or PFS (8.6 months in both groups;  $P = .60$ ) was seen with the addition of cetuximab to FOLFOX or CapeOx as first-line treatment of patients with locally advanced or metastatic colorectal cancer and wild-type *KRAS*.<sup>392</sup> Exploratory analyses of the COIN trial, however, suggest that there may be a benefit to the addition of cetuximab in patients who received FOLFOX instead of CapeOx.<sup>392</sup> Similarly, a recent pooled analysis of the COIN and OPUS studies found that a benefit was suggested in response rate and PFS with the addition of cetuximab to FOLFOX in *KRAS* wild-type patients, although there was no OS benefit.<sup>393</sup>

Notably, more recent trials examining the efficacy of the addition of cetuximab to oxaliplatin-containing regimens in the first-line treatment of patients with advanced or metastatic colorectal cancer and wild-type *KRAS* have not shown any benefit. The addition of cetuximab to the Nordic FLOX regimen showed no benefit in OS or PFS in this population of patients in the randomized phase III NORDIC VII study of the Nordic Colorectal Cancer Biomodulation Group.<sup>394</sup>

In summary, the negative COIN trial showed a marginal benefit in the FOLFOX subset of patients; the NORDIC trial was negative; and the only positive results came from a phase II trial with a primary end point of response rate (OPUS). Because of the lack of convincing benefit and the increased incidence of grade 3 adverse events seen in the COIN trial, the panel does not recommend the use of cetuximab with FOLFOX as initial therapy for patients with advanced or metastatic disease.

### **Panitumumab with FOLFOX**

Panitumumab in combination with either FOLFOX<sup>275,395</sup> or FOLFIRI<sup>286</sup> has also been studied in the first-line treatment of patients with

metastatic colorectal cancer. Results from the large, open-label, randomized PRIME trial comparing panitumumab plus FOLFOX versus FOLFOX alone in patients with *KRAS* wild-type advanced colorectal cancer showed a statistically significant improvement in PFS with the addition of panitumumab (HR, 0.80; 95% CI, 0.67-0.95;  $P = .009$ ), although differences in OS between the arms were not significant.<sup>395</sup> Therefore, the combination of FOLFOX and panitumumab remains an option as initial therapy for patients with advanced or metastatic disease. Importantly, the addition of panitumumab had a detrimental impact on progression-free survival for patients with tumors characterized by mutated *KRAS* in the PRIME trial.<sup>395</sup>

### **The Role of *KRAS* and *BRAF* Status**

The receptor for EGFR has been shown to be overexpressed in 19% of colorectal tumors.<sup>396</sup> EGFR testing of colorectal tumor cells has no proven predictive value in determining likelihood of response to either cetuximab or panitumumab. Data from the BOND study indicated that the intensity of immunohistochemical staining of EGFR in colorectal tumor cells did not correlate with the response rate to cetuximab.<sup>269</sup> A similar conclusion was drawn with respect to panitumumab.<sup>397</sup> Therefore, routine EGFR testing is not recommended, and no patient should be either considered for or excluded from cetuximab or panitumumab therapy based on EGFR test results.

Cetuximab and panitumumab are monoclonal antibodies directed against EGFR that inhibit its downstream signaling pathways, but EGFR status as assessed using immunohistochemistry is not predictive of treatment efficacy.<sup>269,398</sup> Furthermore, cetuximab and panitumumab are only effective in approximately 10% to 20% of patients with colorectal cancer.<sup>269,296,398</sup> The RAS/RAF/MAPK pathway is downstream of EGFR; mutations in components of this pathway are being studied in search of predictive markers for efficacy of these therapies.

Approximately 40% of colorectal cancers are characterized by mutations in codons 12 and 13 in exon 2 of the coding region of the *KRAS* gene.<sup>135,263</sup> A sizable body of literature has shown that these *KRAS* mutations are predictive of lack of response to cetuximab or panitumumab therapy,<sup>263,295,331,371-376,399</sup> and FDA labels for cetuximab and panitumumab specifically state that these agents are not recommended for the treatment of colorectal cancer characterized by these mutations.<sup>368,369</sup> Results are mixed as far as the prognostic value of *KRAS* mutations, and the test is not recommended for prognostic reasons.

A recent retrospective study from De Roock et al<sup>400</sup> raised the possibility that codon 13 mutations (G13D) may not be absolutely predictive of non-response. Another recent retrospective study showed similar results.<sup>401</sup> However, as the article by De Roock et al<sup>400</sup> states, these findings are hypothesis-generating only, and prospective studies are needed to determine if patients with *KRAS* G13D mutations can, in fact, benefit from anti-EGFR therapy. Currently, use of anti-EGFR agents in patients whose tumors have G13D mutations remains investigational, and is not endorsed by the panel for routine practice.

The panel strongly recommends genotyping of tumor tissue (either primary tumor or metastasis) in all patients with metastatic colorectal cancer at diagnosis of stage IV disease. The recommendation for *KRAS* testing, at this point, is not meant to indicate a preference regarding regimen selection in the first-line setting. Rather, this early establishment of *KRAS* status is appropriate to plan for the treatment continuum, so that the information may be obtained in a non-time-sensitive manner and the patient and provider can discuss the implications of a *KRAS* mutation, if present, while other treatment options still exist. Note that because anti-EGFR agents have no role in the management of stage I, II, or III disease, *KRAS* genotyping of

colorectal cancers at these earlier stages is not recommended. *KRAS* mutations are early events in colorectal cancer formation, and therefore a very tight correlation exists between mutation status in the primary tumor and the metastases.<sup>402-404</sup> For this reason, *KRAS* genotyping can be performed on archived specimens of either the primary tumor or a metastasis. Fresh biopsies should not be obtained solely for the purpose of *KRAS* genotyping unless an archived specimen from either the primary tumor or a metastasis is unavailable. The panel recommends that *KRAS* gene testing be performed only in laboratories that are certified under the Clinical Laboratory Improvement Amendments of 1988 (CLIA-88) as qualified to perform highly complex molecular pathology testing.<sup>405</sup> No specific testing methodology is recommended.<sup>406</sup>

Although certain mutations of *KRAS* indicate a lack of response to EGFR inhibitors, many tumors containing wild-type *KRAS* still do not respond to these therapies. Therefore, studies have addressed factors downstream of *KRAS* as possible additional biomarkers predictive of response to cetuximab or panitumumab. Approximately 5% to 9% of colorectal cancers are characterized by a specific mutation in the *BRAF* gene (V600E).<sup>345,407</sup> *BRAF* mutations are, for all practical purposes, limited to tumors that do not have *KRAS* exon 2 mutations.<sup>392,407</sup> Activation of the protein product of the non-mutated *BRAF* gene occurs downstream of the activated K-RAS protein in the EGFR pathway; the mutated *BRAF* protein product is believed to be constitutively active,<sup>408-410</sup> thereby putatively bypassing inhibition of EGFR by cetuximab or panitumumab.

The utility of *BRAF* status as a predictive marker is unclear. Limited data from unplanned retrospective subset analyses of patients with metastatic colorectal cancer treated in the first-line setting suggest that although a *BRAF* V600E mutation confers a poor prognosis regardless

of treatment, patients with disease characterized by this mutation may receive some benefit from the addition of cetuximab to front-line therapy.<sup>387,411</sup> On the other hand, results from the randomized phase III MRC COIN trial suggest that cetuximab may have no effect or even a detrimental one in patients with *BRAF*-mutated tumors treated with CapeOx or FOLFOX in the first-line setting.<sup>392</sup> Overall, the panel believes that there are insufficient data to guide the use of anti-EGFR therapy in the first-line setting with active chemotherapy based on *BRAF* V600E mutation status.

In subsequent lines of therapy, retrospective evidence suggests that mutated *BRAF* is a marker of resistance to anti-EGFR therapy in the non-first-line setting of metastatic disease.<sup>412-414</sup> A retrospective study of 773 primary tumor samples from chemotherapy-refractory patients showed that *BRAF* mutations conferred a significantly lower response rate to cetuximab (2/24; 8.3%) compared with tumors with wild-type *BRAF* (124/326; 38.0%;  $P = .0012$ ).<sup>415</sup> Furthermore, recently reported prospective data from the multicenter randomized controlled PICCOLO trial is consistent with this conclusion, with a detrimental effect seen for the addition of panitumumab to irinotecan in the non-first-line setting.<sup>389</sup>

Despite uncertainty over its role as a predictive marker, it is clear that mutations in *BRAF* are a strong prognostic marker.<sup>135,387,392,416-418</sup> A recent prospective analysis of tissues from patients with stage II and III colon cancer enrolled in the PETACC-3 trial showed that the *BRAF* mutation is prognostic for OS in patients with MSI-L or MSS tumors (HR, 2.2; 95% CI; 1.4-3.4;  $P = .0003$ ).<sup>135</sup> Moreover, an updated analysis of the CRYSTAL trial showed that patients with metastatic colorectal tumors carrying a *BRAF* mutation have a worse prognosis than those with the wild-type gene.<sup>387</sup> Additionally, *BRAF* mutation status predicted OS in the AGITG MAX trial, with an HR of 0.49 (CI, 0.33-0.73;  $P = .001$ ).<sup>416</sup> The OS for patients with *BRAF* mutations in the COIN trial was

8.8 months, while those with *KRAS* mutations and wild-type tumors had OS times of 14.4 months and 20.1 months, respectively.<sup>392</sup>

For patients with *KRAS* wild-type tumors, the panel includes the option of *BRAF* genotyping of tumor tissue (either primary tumor or metastasis<sup>419</sup>) at diagnosis of *KRAS* wild-type stage IV disease. Testing for the *BRAF* V600E mutation can be performed on formalin-fixed paraffin-embedded tissues and is usually performed by PCR amplification and direct DNA sequence analysis. Allele-specific PCR is another acceptable method for detecting this mutation. As with *KRAS* testing, *BRAF* testing should be performed only in CLIA-88 molecular pathology laboratories.

### Therapy After Progression

Decisions regarding therapy after progression of metastatic disease depend on previous therapies. The panel recommends against the use of capecitabine, mitomycin, alfa-interferon, taxanes, methotrexate, pemetrexed, sunitinib, sorafenib, erlotinib, or gemcitabine, either as single agents or in combination, as salvage therapy in patients exhibiting disease progression after treatment with standard therapies. These agents have not been shown to be effective in this setting. Furthermore, no objective responses were observed when single-agent capecitabine was administered in a phase II study of patients with colorectal cancer resistant to 5-FU.<sup>420</sup>

The recommended therapy options after first progression for patients who have received prior 5-FU/LV-based or capecitabine-based therapy are dependent on the initial treatment regimen:

- For patients who received a FOLFOX or CapeOx-based regimen for initial therapy, FOLFIRI or irinotecan alone or with cetuximab or

panitumumab (*KRAS* wild-type tumor only), bevacizumab, or ziv-aflibercept are recommended options.

- For patients who received a FOLFIRI-based regimen as initial treatment, FOLFOX or CapeOx alone<sup>421</sup> or with bevacizumab; cetuximab or panitumumab plus irinotecan; or single-agent cetuximab or panitumumab (for those not appropriate for the combination with irinotecan) are recommended options.
- For patients who received 5-FU/LV or capecitabine without oxaliplatin or irinotecan as initial therapy, options after first progression include FOLFOX, CapeOx, FOLFIRI, single-agent irinotecan, or irinotecan plus oxaliplatin (IROX). These can be variously combined with bevacizumab or ziv-aflibercept.
- For patients who received FOLFOXIRI as initial therapy, cetuximab or panitumumab plus irinotecan or cetuximab or panitumumab alone are recommended options for those with wild-type *KRAS* gene.

Results from a randomized study to evaluate the efficacy of FOLFIRI and FOLFOX6 regimens as initial therapy and to determine the effect of using sequential therapy with the alternate regimen after first progression showed neither sequence to be significantly superior with respect to PFS or median OS.<sup>304</sup> A combined analysis of data from 7 recent phase III clinical trials in advanced colorectal cancer provided support for a correlation between an increase in median survival and administration of all of the 3 cytotoxic agents (ie, 5-FU/LV, oxaliplatin, irinotecan) at some point in the continuum of care.<sup>422</sup> Furthermore, OS was not found to be associated with the order in which these drugs were received. Single-agent irinotecan administered after first progression has been shown to significantly improve OS relative to best

supportive care<sup>270</sup> or infusional 5-FU/LV.<sup>423</sup> In the study of Rougier et al,<sup>423</sup> median PFS was 4.2 months for irinotecan versus 2.9 months for 5-FU ( $P=0.030$ ), whereas Cunningham et al<sup>270</sup> reported a survival rate at 1 year of 36.2% in the group receiving irinotecan versus 13.8% in the supportive-care group ( $P = .0001$ ). Furthermore, no significant differences in OS were observed in the Intergroup N9841 trial when FOLFOX was compared with irinotecan monotherapy after first progression of metastatic colorectal cancer.<sup>424</sup>

### *Bevacizumab in the Non-First-Line Setting*

In the TML trial, patients with metastatic colorectal cancer who progressed on regimens containing bevacizumab received second-line therapy consisting of a different chemotherapy regimen with or without bevacizumab.<sup>425</sup> This study met its primary end point, with patients continuing on bevacizumab having a modest improvement in OS (11.2 months vs. 9.8 months; HR, 0.81; 95% CI, 0.69–0.94;  $P = .0062$ ).

The continuation of bevacizumab following progression on bevacizumab was also studied in a community oncology setting through a retrospective analysis of 573 patients from the US Oncology iKnowMed electronic medical record system.<sup>426</sup> Bevacizumab beyond progression was associated with a longer OS (HR, 0.76; 95% CI, 0.61–0.95) and a longer post-progression OS (HR, 0.74; 95% CI, 0.60–0.93) on multivariate analysis.

Overall, these data (along with data from the VELOUR trial, discussed below) show that the continuation of VEGF blockade in second-line therapy offers a very modest but statistically significant OS benefit. The panel added the continuation of bevacizumab to the second-line treatment options for the 2013 versions of the NCCN Guidelines for Colon and Rectal Cancers. It may be added to any regimen that does not contain an EGFR inhibitor or ziv-aflibercept. The panel recognizes

the lack of data suggesting a benefit to bevacizumab with irinotecan alone in this setting, but believes that the option is acceptable, especially in patients who failed a 5-FU- or capecitabine-based regimen.

It may also be appropriate to consider adding bevacizumab to chemotherapy after progression of metastatic disease if it was not used in initial therapy.<sup>277</sup> The randomized phase III ECOG E3200 study in patients who experienced progression through a first-line non-bevacizumab-containing regimen showed that the addition of bevacizumab to second-line FOLFOX modestly improved survival.<sup>277</sup> Median OS was 12.9 months for patients receiving FOLFOX plus bevacizumab compared with 10.8 months for patients treated with FOLFOX alone ( $P = .0011$ ).<sup>277</sup> Use of single-agent bevacizumab is not recommended, because it was shown to have inferior efficacy compared with the FOLFOX alone or FOLFOX plus bevacizumab treatment arms.<sup>277</sup>

### *Cetuximab and Panitumumab in the Non-First-Line Setting*

For patients with wild-type *KRAS* who experienced progression on therapies *not* containing an EGFR inhibitor, cetuximab or panitumumab plus irinotecan, cetuximab or panitumumab plus FOLFIRI, or single-agent cetuximab or panitumumab<sup>373</sup> is recommended. For patients with wild-type *KRAS* progressing on therapies that *did* contain an EGFR inhibitor, administration of an EGFR inhibitor is not recommended in subsequent lines of therapy. Although no head-to-head studies have compared cetuximab and panitumumab, similar response rates have been observed when each agent was studied as monotherapy after progression. No data support switching to either cetuximab or panitumumab after failure of the other drug, and the panel recommends against this practice. If the patient does not experience response to

oxaliplatin, irinotecan, and an EGFR inhibitor, the panel recommends best supportive care or enrollment on a clinical trial.

Panitumumab has been studied as a single agent in the setting of metastatic colorectal cancer for patients with disease progression on oxaliplatin/irinotecan-based chemotherapy.<sup>296</sup> In a retrospective analysis of the subset of patients in this trial with known *KRAS* tumor status, the benefit of panitumumab versus best supportive care was shown to be enhanced in patients with *KRAS* wild-type tumors.<sup>263</sup> Progression-free survival was 12.3 weeks versus 7.3 weeks in favor of the panitumumab arm. Response rates to panitumumab were 17% versus 0% in the wild-type and mutant arms, respectively.<sup>263</sup>

Panitumumab has also been studied in combination therapy in the setting of progressing metastatic colorectal cancer. Among patients with *KRAS* wild-type tumors enrolled in the large Study 181 comparing FOLFIRI alone versus FOLFIRI plus panitumumab as second-line therapy for metastatic colorectal cancer, addition of the biologic agent was associated with improvement in median PFS (5.9 vs. 3.9 months; HR, 0.73; 95% CI, 0.59-0.90;  $P = .004$ ), although differences in OS between the arms did not reach statistical significance.<sup>288</sup> These results were confirmed in the final results of study 181.<sup>390</sup> In addition, secondary analysis from the STEPP trial showed that panitumumab in combination with irinotecan-based chemotherapy in second-line therapy has an acceptable toxicity profile.<sup>388</sup> The randomized multicenter PICCOLO trial, which assessed the safety and efficacy of irinotecan/panitumumab, did not meet its primary end point of improved OS in patients with wild-type *KRAS* tumors.<sup>389</sup>

Cetuximab has been studied both as a single agent<sup>269,373,381,398</sup> and in combination with irinotecan<sup>269,427</sup> in patients experiencing disease progression on initial therapy not containing cetuximab or panitumumab

for metastatic disease. Results of a large phase III study comparing irinotecan with or without cetuximab did not show a difference in OS, but showed significant improvement in response rate and in median PFS with irinotecan and cetuximab compared with irinotecan alone.<sup>428</sup> Importantly, *KRAS* status was not determined in this study and toxicity was higher in the cetuximab-containing arm (eg, rash, diarrhea, electrolyte imbalances).<sup>428</sup>

In a retrospective analysis of the subset of patients with known *KRAS* tumor status receiving cetuximab monotherapy as second-line therapy,<sup>381</sup> the benefit of cetuximab versus best supportive care was shown to be enhanced in patients with *KRAS* wild-type tumors.<sup>373</sup> For those patients, median PFS was 3.7 versus 1.9 months (HR, 0.40; 95% CI, 0.30-0.54;  $P < .001$ ) and median OS was 9.5 versus 4.8 months (HR, 0.55; 95% CI, 0.41-0.74;  $P < .001$ ) in favor of the cetuximab arm.<sup>373</sup>

### *Ziv-Aflibercept*

Ziv-aflibercept is a recombinant protein that has part of the human VEGF receptors 1 and 2 fused to the Fc portion of human IgG1.<sup>429</sup> It is designed to function as a VEGF trap to prevent activation of VEGF receptors and thus inhibit angiogenesis. The VELOUR trial tested second-line ziv-aflibercept in patients with metastatic colorectal cancer who failed one regimen containing oxaliplatin. The trial met its primary end point with a small improvement in OS (13.5 months for FOLFIRI/ziv-aflibercept vs. 12.1 months for FOLFIRI/placebo; HR, 0.82; 95% CI, 0.71-0.94;  $P = .003$ ).<sup>298</sup>

Ziv-aflibercept has only shown activity when given in conjunction with FOLFIRI in FOLFIRI-naïve patients. There are no data to suggest activity of FOLFIRI plus ziv-aflibercept in patients who progressed on FOLFIRI plus bevacizumab or vice-versa, and no data to suggest

activity of single agent ziv-aflibercept. Thus, the panel added ziv-aflibercept as a second-line treatment option in combination with FOLFIRI or irinotecan only following progression on therapy not containing irinotecan.

Adverse events associated with ziv-aflibercept treatment in the VELOUR trial led to discontinuation in 26.6% of patients compared to 12.1% discontinuation in the placebo group.<sup>298</sup> The most common causes for discontinuation were asthenia/fatigue, infections, diarrhea, hypertension, and venous thromboembolic events.

### *Regorafenib*

Regorafenib is a small molecule inhibitor of multiple kinases (including VEGF receptors, fibroblast growth factor (FGF) receptors, platelet-derived growth factor (PDGF) receptors, BRAF, KIT, and RET) that are involved with various processes including tumor growth and angiogenesis.<sup>430</sup> The phase III CORRECT trial randomized 760 patients who progressed on standard therapy to best supportive care with placebo or regorafenib.<sup>281,431</sup> The trial met its primary end point of OS (6.4 months for regorafenib vs. 5.0 months for placebo; HR, 0.77; 95% CI, 0.64-0.94;  $P = .005$ ). PFS was also significantly but modestly improved (1.9 months vs. 1.7 months; HR, 0.49; 95% CI, 0.42-0.58;  $P < .000001$ ).

Regorafenib has only shown activity in patients who have progressed on all standard therapy. Therefore, the panel added regorafenib as an additional line of therapy for patients with metastatic colorectal cancer refractory to chemotherapy. For patients with mutant *KRAS*, regorafenib can be used in the third-line setting; patients with wild-type *KRAS* can receive regorafenib as a third or fourth line of therapy.

The most common grade 3 or higher adverse events in the regorafenib arm of the CORRECT trial were hand-foot skin reaction (17%), fatigue (10%), hypertension (7%), diarrhea (7%), and rash/desquamation (6%).<sup>281,431</sup> Severe and fatal liver toxicity occurred in 0.3% of 1100 patients treated with regorafenib across all trials.<sup>430</sup>

### Workup and Management of Synchronous Metastatic Disease

The workup for patients in whom metastatic synchronous adenocarcinoma from the large bowel (eg, colorectal liver metastases) is suspected should include a total colonoscopy, CBC, chemistry profile, CEA determination, needle biopsy if indicated, and CT scan with intravenous contrast of the chest, abdomen, and pelvis.<sup>75</sup> MRI with intravenous contrast should be considered if CT is inadequate. The panel also recommends tumor *KRAS* gene status testing at diagnosis of metastatic disease and consideration of *BRAF* genotyping for all patients with *KRAS* wild-type metastatic colon cancer (see *The Role of KRAS and BRAF Status*, above).

The panel strongly discourages the routine use of PET/CT scanning for staging, baseline imaging, or routine follow-up, and recommends consideration of a preoperative PET/CT scan at baseline only if prior anatomic imaging indicates the presence of potentially surgically curable M1 disease. The purpose of this PET/CT scan is to evaluate for unrecognized metastatic disease that would preclude the possibility of surgical management. Patients with clearly unresectable metastatic disease should not have baseline PET/CT scans. The panel also notes that PET/CT scans should not be used to assess response to chemotherapy, because a PET/CT scan can become transiently negative after chemotherapy (eg, in the presence of necrotic lesions).<sup>432</sup> False-positive PET/CT scan results can occur in the presence of tissue inflammation after surgery or infection.<sup>432</sup> An MRI with intravenous

contrast can be considered as part of the preoperative evaluation of patients with potentially surgically resectable M1 liver disease. For example, an MRI with contrast may be of use when the PET and CT scan results are inconsistent with respect to the extent of disease in the liver.

The criterion of potential surgical cure includes patients with metastatic disease that is not initially resectable but for whom a surgical cure may become possible after preoperative chemotherapy. In most cases, however, the presence of extrahepatic disease will preclude the possibility of resection for cure; *conversion to resectability* for the most part refers to a patient with liver-only disease that, because of involvement of critical structures, cannot be resected unless regression is accomplished with chemotherapy (see *Conversion to Resectability*, above).

Close communication among members of the multidisciplinary treatment team is recommended, including an upfront evaluation by a surgeon experienced in the resection of hepatobiliary or lung metastases.

### Resectable Synchronous Liver or Lung Metastases

When patients present with colorectal cancer and synchronous liver metastases, resection of the primary tumor and liver can be performed in a simultaneous or staged approach.<sup>433-435</sup> When the remnant liver is insufficient in size based on cross-sectional imaging volumetrics, preoperative portal vein embolization of the involved liver can be performed to expand the future liver remnant.<sup>436</sup> Colorectal metastatic disease can also occur in the lung.<sup>169</sup> Most of the treatment recommendations discussed for metastatic colorectal liver disease also apply to the treatment of colorectal pulmonary metastases.<sup>437</sup> Combined



pulmonary and hepatic resections of resectable metastatic disease have been performed in very highly selected cases.<sup>191,438,439</sup>

If a patient with resectable liver or lung metastases is a candidate for surgery, the panel recommends the following options: 1) colectomy and synchronous or subsequent liver (or lung) resection,<sup>176,184</sup> followed by adjuvant chemotherapy (FOLFOX or CapeOx, preferred<sup>106,317</sup>); 2) neoadjuvant chemotherapy for 2 to 3 months (ie, FOLFIRI, FOLFOX,<sup>175</sup> or CapeOx chemotherapy alone or with bevacizumab; FOLFIRI or FOLFOX regimens with panitumumab; FOLFIRI with cetuximab), followed by synchronous or staged colectomy with liver or lung resection; or 3) colectomy followed by adjuvant chemotherapy (see neoadjuvant options discussed earlier) and a staged resection of metastatic disease. Overall, combined neoadjuvant and adjuvant treatments should not exceed 6 months.

In the case of liver metastases only, HAI therapy with or without systemic 5-FU/LV (category 2B) remains an option at centers with experience in the surgical and medical oncologic aspects of this procedure.

#### **Unresectable Synchronous Liver or Lung Metastases**

For patients with metastatic disease that is deemed to be potentially convertible (see *Conversion to Resectability*, above),<sup>264</sup> chemotherapy regimens with high response rates should be considered, and these patients should be reevaluated for resection after 2 months of preoperative chemotherapy and every 2 months thereafter while undergoing this therapy. If bevacizumab is included as a component of the conversion therapy, an interval of at least 6 weeks between the last dose of bevacizumab and surgery should be applied, with a 6- to 8-week postoperative period before re-initiation of bevacizumab. Patients with disease converted to a resectable state should undergo

synchronized or staged resection of colon and metastatic cancer, including treatment with pre- and postoperative chemotherapy for a preferred total perioperative duration of 6 months. Recommended options for adjuvant therapy for these patients include active chemotherapy regimens for advanced or metastatic disease (category 2B); observation or a shortened course of chemotherapy can also be considered for patients who have completed preoperative chemotherapy. In the case of liver metastases only, HAI therapy with or without systemic 5-FU/LV (category 2B) remains an option at centers with experience in the surgical and medical oncologic aspects of this procedure.

Patients with potentially convertible metastatic disease that is not responding to therapy should receive chemotherapy for advanced or metastatic disease with treatment selection based partly on whether the patient is an appropriate candidate for intensive therapy. Debulking surgery or ablation without curative intent is not recommended.

For patients with liver only or lung only disease that is deemed unresectable (see *Determining Resectability*, above), the panel recommends chemotherapy corresponding to initial therapy for metastatic disease (eg, FOLFIRI, FOLFOX, or CapeOx chemotherapy alone or with bevacizumab; FOLFIRI or FOLFOX with panitumumab; FOLFIRI with cetuximab; or FOLFOXIRI alone [category 2B]).

Results from a recent study suggest that there may be some benefit in both OS and PFS from resection of the primary in the setting of unresectable colorectal metastases.<sup>440</sup> Other retrospective analyses also have shown a potential benefit.<sup>441,442</sup> On the other hand, the prospective, multicenter phase II NSABP C-10 trial showed that patients with an asymptomatic primary colon tumor and unresectable metastatic disease who received mFOLFOX6 with bevacizumab experienced an



Close communication between members of the multidisciplinary treatment team is recommended, including upfront evaluation by a surgeon experienced in the resection of hepatobiliary and lung metastases. The management of metachronous metastatic disease is distinguished from that of synchronous disease through also including an evaluation of the chemotherapy history of the patient and through the absence of colectomy.

Patients with resectable disease are classified according to whether they have undergone previous chemotherapy. For patients who have resectable metastatic disease, treatment is resection with 6 months of perioperative chemotherapy (pre- or postoperative or a combination of both). There are also cases when perioperative chemotherapy is not recommended in metachronous disease. In particular, patients with a history of previous chemotherapy and an upfront resection can be observed or may be given an active regimen for advanced disease. Observation is preferred if oxaliplatin-based therapy was previously administered. In addition, observation is an appropriate option for patients whose tumors grew through neoadjuvant treatment. For patients without a history of chemotherapy use, FOLFOX or CapeOx are preferred following an upfront resection.

Patients determined to have unresectable disease through cross-sectional imaging scan (including those considered potentially convertible) should receive an active chemotherapy regimen based on prior chemotherapy history (see *Therapy after Progression*, above). In the case of liver metastases only, HAI therapy with or without systemic 5-FU/LV (category 2B) is an option at centers with experience in the surgical and medical oncologic aspects of this procedure. Patients receiving palliative chemotherapy should be monitored with CT or MRI scans approximately every 2 to 3 months.

### End Points for Advanced Colorectal Cancer Clinical Trials

In the past few years, there has been much debate over what end points are most appropriate for clinical trials in advanced colorectal cancer.<sup>448</sup> Quality of life is an outcome that is rarely measured but of unquestioned clinical relevance.<sup>449</sup> While OS is also of clear clinical relevance, it is often not used because large numbers of patients and long follow-up periods are required.<sup>449</sup> PFS is often used as a surrogate, but its correlation with OS is inconsistent at best, especially when subsequent lines of therapy are administered.<sup>449,450</sup> The GROUP Español Multidisciplinar en Cancer Digestivo (GEMCAD) recently proposed particular aspects of clinical trial design to be incorporated into trials that use PFS as an end point.<sup>451</sup>

A recent study, in which individual patient data from 3 randomized controlled trials were pooled, tested end points that take into account subsequent lines of therapy: duration of disease control, which is the sum of PFS times of each active treatment; and time to failure of strategy, which includes intervals between treatment courses and ends when the planned lines of treatment end (because of death, progression, or administration of a new agent).<sup>450</sup> The authors found a better good correlation between these end points and OS than between PFS and OS. Further evaluation of these and other surrogate end points is warranted.

### Posttreatment Surveillance

After curative-intent surgery and adjuvant chemotherapy, if administered, post-treatment surveillance of patients with colorectal cancer is performed to evaluate for possible therapeutic complications, discover a recurrence that is potentially resectable for cure, and identify new metachronous neoplasms at a preinvasive stage. Advantages of

more intensive follow-up of patients with stage II and/or stage III disease have been shown prospectively in several studies<sup>452-454</sup> and in 3 recent meta-analyses of randomized controlled trials designed to compare low- and high-intensity programs of surveillance.<sup>455-458</sup> Other recent studies impacting the issue of post-treatment surveillance of colorectal cancer include results from an analysis of data from 20,898 patients enrolled in 18 large, adjuvant, colon cancer, randomized trials that showed that 80% of recurrences occurred in the first 3 years after surgical resection of the primary tumor.<sup>115</sup>

Intensive postoperative surveillance has also been suggested to be of benefit to patients with stage I and IIA disease.<sup>459</sup> Furthermore, a population-based report indicates increased rates of resectability and survival in patients treated for local recurrence and distant metastases of colorectal cancer in more recent years, thereby providing support for more intensive post-treatment follow-up in these patients.<sup>460</sup> Nevertheless, controversies remain regarding selection of optimal strategies for following up patients after potentially curative colorectal cancer surgery.<sup>461,462</sup>

For patients with stage I disease, the panel believes that a less intensive surveillance schedule is appropriate, because of the low risk of recurrence and the harms associated with surveillance. Possible harms include the radiation exposure with repeated CT scans, the psychological stress associated with surveillance visits and scans, and the stress and risks from following up false-positive results. Therefore, for patients with stage I disease, the panel recommends colonoscopy at 1 year. Repeat colonoscopy is recommended at 3 years, and then every 5 years thereafter, unless advanced adenoma (villous polyp, polyp >1 cm, or high-grade dysplasia) is found. In this case, colonoscopy should be repeated in 1 year.<sup>463</sup>

The following panel recommendations for post-treatment surveillance pertain to patients with stage II/III disease who have undergone successful treatment (ie, no known residual disease). History and physical examination should be given every 3 to 6 months for 2 years, and then every 6 months for a total of 5 years. A CEA test is recommended at baseline and every 3 to 6 months for 2 years,<sup>464</sup> then every 6 months for a total of 5 years for patients with stage III disease and those with stage II disease if the clinician determines that the patient is a potential candidate for aggressive curative surgery.<sup>455,464</sup> Colonoscopy is recommended at approximately 1 year after resection (or at 3–6 months postresection if not performed preoperatively because of an obstructing lesion). Repeat colonoscopy is typically recommended at 3 years, and then every 5 years thereafter, unless follow-up colonoscopy indicates advanced adenoma (villous polyp, polyp >1 cm, or high-grade dysplasia), in which case colonoscopy should be repeated in 1 year.<sup>463</sup> More frequent colonoscopies may be indicated in patients who present with colon cancer before 50 years of age. Chest, abdominal, and pelvic CT scan are recommended annually for up to 5 years in patients with stage III disease and those with stage II disease at a high risk for recurrence.<sup>455,462</sup> Routine CEA monitoring and CT scanning are not recommended beyond 5 years. Routine use of PET/CT to monitor for disease recurrence is not recommended.<sup>462</sup> The CT that accompanies a PET/CT is usually a noncontrast CT, and therefore not of ideal quality for routine surveillance.

Surveillance colonoscopies are primarily aimed at identifying and removing metachronous polyps,<sup>463</sup> because data show that patients with a history of colorectal cancer have an increased risk of developing second cancers, particularly in the first 2 years after resection.<sup>463,465</sup> Furthermore, use of post-treatment surveillance colonoscopy has not been shown to improve survival through the early detection of

recurrence of the original colorectal cancer.<sup>463</sup> The recommended frequency of post-treatment surveillance colonoscopies is higher (ie, annually) for patients with Lynch syndrome.<sup>463</sup> CT scan is recommended to monitor for the presence of potentially resectable metastatic lesions, primarily in the lung and liver.<sup>455</sup> Hence, CT scan is not routinely recommended in asymptomatic patients who are not candidates for potentially curative resection of liver or lung metastases.<sup>455,462</sup>

Panel recommendations for surveillance of patients with stage IV colorectal cancer with no NED after curative-intent surgery and subsequent adjuvant treatment are similar to those listed for patients with stage II/III disease, except that certain evaluations are performed more frequently. Specifically, the panel recommends that these patients undergo contrast-enhanced CT scan of the chest, abdomen, and pelvis every 3 to 6 months in the first 2 years after adjuvant treatment and then every 6 to 12 months for up to a total of 5 years. CEA testing is recommended every 3 to 6 months for the first 2 years and then every 6 months for a total of 5 years, as in early-stage disease. Again, routine use of PET/CT scans for surveillance is not recommended.

### Managing an Increasing CEA Level

Managing patients with an elevated CEA level after resection should include colonoscopy; chest, abdominal, and pelvic CT scans; physical examination; and consideration of PET/CT scan. If imaging study results are normal in the face of a rising CEA, repeat CT scans are recommended every 3 months until either disease is identified or CEA level stabilizes or declines. Panel opinion was divided on the usefulness of PET/CT scan in the scenario of an elevated CEA with negative, good-quality CT scans (ie, some panel members favored use of PET/CT in this scenario whereas others noted that the likelihood of PET/CT identifying surgically curable disease in the setting of negative

good-quality CT scans is vanishingly small). Use of PET/CT scans in this scenario is permissible within these guidelines. The panel does not recommend a so-called blind or CEA-directed laparotomy or laparoscopy for patients whose workup for an increased CEA level is negative,<sup>466</sup> nor do they recommend use of anti-CEA-radiolabeled scintigraphy.

### Survivorship

Post-treatment surveillance for all patients also includes a survivorship care plan involving disease-preventive measures, such as immunizations; early disease detection through periodic screening for second primary cancers (eg, breast, cervical, or prostate cancers); and routine good medical care and monitoring. Additional health monitoring should be performed as indicated under the care of a primary care physician. Survivors are encouraged to maintain a therapeutic relationship with a primary care physician throughout their lifetime.

Other recommendations include monitoring for late sequelae of colon cancer or the treatment of colon cancer, such as chronic diarrhea or incontinence (eg, patients with stoma)<sup>467-471</sup> Specific management interventions to address these and other side effects are described in a recent review,<sup>472</sup> and a survivorship care plan for patients with colorectal cancer was recently published.<sup>473</sup>

Evidence also indicates that certain lifestyle characteristics, such as smoking cessation, maintaining a healthy body mass index (BMI), engaging in regular exercise, and making certain dietary choices are associated with improved outcomes after treatment for colon cancer. For example, a retrospective study of patients with stage II and III colon cancer enrolled in NSABP trials from 1989 to 1994 showed that patients with a BMI of 35 kg/m<sup>2</sup> or greater had an increased risk of disease recurrence and death.<sup>474</sup> In a prospective observational study of patients

with stage III colon cancer enrolled in the CALGB 89803 adjuvant chemotherapy trial, DFS was found to be directly related to how much exercise these patients received.<sup>475</sup> Furthermore, a diet consisting of more fruits, vegetables, poultry, and fish, and less red meat, and higher in whole grains and lower in refined grains and concentrated sweets, was found to be associated with an improved outcome in terms of cancer recurrence or death.<sup>476</sup> In addition, a recent study of a large cohort of men treated for stage I through III colorectal cancer showed an association between increased physical activity and lower rates of colorectal cancer-specific mortality and overall mortality.<sup>477</sup> A discussion of lifestyle characteristics that may be associated with a decreased risk of colon cancer recurrence, such as those recommended by the American Cancer Society,<sup>478</sup> also provides “a teachable moment” for the promotion of overall health, and an opportunity to encourage patients to make choices and changes compatible with a healthy lifestyle.

The panel recommends that a prescription for survivorship and transfer of care to the primary care physician be written if the primary physician will be assuming cancer surveillance responsibilities.<sup>479</sup> The prescription should include an overall summary of treatments received, including surgeries, radiation treatments, and chemotherapy. The possible clinical course should be described, including the expected time to resolution of acute toxicities, long-term effects of treatment, and possible late sequelae of treatment. Surveillance recommendations should be included, as should a delineation of the appropriate timing of transfer of care with specific responsibilities identified for the primary care physician and the oncologist.

### Summary

The panel believes that a multidisciplinary approach is necessary for managing colorectal cancer. The panel endorses the concept that

treating patients in a clinical trial has priority over standard or accepted therapy.

The recommended surgical procedure for resectable colon cancer is an en bloc resection and adequate lymphadenectomy. Adequate pathologic assessment of the resected lymph nodes is important with a goal of evaluating at least 12 nodes. Adjuvant therapy with FOLFOX (category 1, preferred), FLOX (category 1), CapeOx (category 1), 5-FU/LV (category 2A), or capecitabine (category 2A) is recommended by the panel for patients with stage III disease. Adjuvant therapy for patients with high-risk stage II disease is also an option; the panel recommends 5-FU/LV with or without oxaliplatin (FOLFOX or FLOX) or capecitabine with or without oxaliplatin (category 2A for all treatment options). Patients with metastatic disease in the liver or lung should be considered for surgical resection if they are candidates for surgery and if all original sites of disease are amenable to resection (R0) and/or ablation. Preoperative chemotherapy can be considered as initial therapy in patients with synchronous or metachronous resectable metastatic disease. When a response to chemotherapy would likely convert a patient from an unresectable to a resectable state (ie, conversion therapy), this therapy should be initiated. Adjuvant chemotherapy should be considered after resection of liver or lung metastases.

The recommended post-treatment surveillance program includes serial CEA determinations, and periodic chest, abdominal, and pelvic CT scans; colonoscopic evaluations; and a survivorship plan to manage long-term side effects of treatment, facilitate disease prevention, and promote a healthy lifestyle.

Recommendations for patients with disseminated metastatic disease represent a continuum of care in which lines of treatment are blurred



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rather than discrete. Principles to consider at initiation of therapy include pre-planned strategies for altering therapy for patients in both the presence and absence of disease progression, including plans for adjusting therapy for patients who experience certain toxicities. Recommended initial therapy options for advanced or metastatic disease depend on whether the patient is appropriate for intensive therapy. The more intensive initial therapy options include FOLFOX, FOLFIRI, CapeOx, and FOLFOXIRI (category 2B). Addition of a biologic agent (eg, bevacizumab, cetuximab, panitumumab) is either recommended or listed as an option in combination with some of these regimens, depending on available data. Chemotherapy options for patients with progressive disease depend on the choice of initial therapy. The panel endorses the concept that treating patients in a clinical trial has priority over standard treatment regimens.



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