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Intensity of Follow-up after Pancreatic Cancer Resection

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Abstract

The prognosis of patients diagnosed with pancreatic adenocarcinoma remains dismal. Of the 15–20 % of patients who are candidates for potentially curative resection, 66–92 % will develop recurrent disease. Although guidelines for surveillance in the postoperative setting exist, they are not evidence based, and there is wide variability of strategies utilized. Current surveillance guidelines as suggested by the National Comprehensive Cancer Network (NCCN) include routine history and physical, measurement of serum cancer-associated antigen 19-9 (CA19-9) levels, and computed tomographic imaging at 3- to 6-month intervals for the first 2 years, and annually thereafter. However, the lack of prospective clinical data examining the efficacy of different surveillance strategies has led to a variability of the intensity of follow-up and a lack of consensus on its necessity and efficacy. Recent therapeutic advances may have the potential to significantly alter survival after recurrence, but a careful consideration of current surveillance strategies should be undertaken to optimize existing approaches in the face of high recurrence and low survival rates.

Pancreatic cancer is the fourth leading cause of cancer-related death in the United States.¹ The 5-year survival rate for all patients diagnosed with pancreatic adenocarcinoma (PDAC) remains at approximately 5 % and has not changed in the last three decades.² Of all patients diagnosed with PDAC, nearly 85 % will present with advanced disease and are not candidates for surgical resection. Even the remaining 15–20 % of patients who undergo potentially curative resection face a 66–92 % risk of recurrence within 2 years of resection, and the long-term prognosis for these patients remains bleak.^{3,4}

Despite the poor long-term survival and extremely high risk of recurrence, no evidence-based guidelines for surveillance of these patients after resection exist. Careful follow-up of patients after surgical resection, although common, presumes that there are effective therapeutic options to utilize should the disease recur. Follow-up, then, should therefore be considered in the context of its ability to improve survival outcomes after recurrence. Furthermore, follow-up recommendations should be designed in such a way that reflects our current understanding of the patterns of recurrence. Current guidelines from the National Comprehensive Cancer Network (NCCN) and the European Society of Medical Oncology

(ESMO), however, rely on low-level evidence and expert opinion, so there is no clear consensus on the appropriate method of surveillance after surgical resection.

In this review we will examine the existing evidence in order to identify effective approaches for surveillance in patients with PDAC after surgical resection. Among the factors to consider are the appropriate use of imaging and laboratory testing of tumor markers, balanced against the performance status and risk for recurrence in the individual patient. Additionally, it is worthwhile to consider these practices in the context of their cost, both monetary and emotional, compared to the potential survival benefit, as currently there is no clear evidence that intensive follow-up improves survival in PDAC.

RECURRENCE RISK AND THERAPEUTIC STRATEGIES

Five-year survival after surgical resection of PDAC is 18–27 % and correlates with resection margin status (R0 vs. R1) and lymph node metastases.^{5–10} The rate of R1 resections has been reported to range from as low as 18 % to as high as 85 %.¹¹ This is important because resection margin status is a critical factor in determining the risk of recurrence. The majority of recurrences occur within 2 years after resection and can be locoregional and/or to distant sites, including the liver, lung, or peritoneal cavity.¹² A rapid autopsy series of patients with known PDAC found up to 30 % died with locally destructive disease with no evidence of distant metastasis, while 70 % died with widespread metastatic disease.¹³

For the last two decades, the primary treatment for PDAC recurrence has been palliative gemcitabine therapy. In the initial study that established gemcitabine treatment for advanced PDAC, gemcitabine improved survival by 1 month compared with 5-fluorouracil (5-FU). Furthermore, patients treated with gemcitabine tolerated the treatment without significant toxicity and had improved clinical benefit—a composite of measures for pain, Karnofsky performance status, and weight (23.8 vs. 4.8 %, $P = 0.0022$).¹⁴ The improvement in clinical benefit response is important, especially in symptomatic patients, as most chemotherapeutic regimens are associated with significant side effects.

Recently, promising results have been seen with newer regimens including 5-FU, irinotecan, and oxaliplatin (FOLFIRINOX) and gemcitabine plus nab-paclitaxel.^{15–17} FOLFIRINOX therapy improved overall survival (OS) of patients with metastatic PDAC by 4.7 months (11.1 vs. 6.4 months, $P < 0.001$) compared with gemcitabine therapy alone. Very recently, the combination of nab-paclitaxel and gemcitabine was demonstrated to improve OS by 1.8 months (8.5 vs. 6.7 months, $P < 0.001$) compared with gemcitabine alone in a phase III clinical trial.^{7,15} Despite these therapeutic advances in terms of survival rates, many patients will not be able to tolerate these potent regimens because of their significant toxicity. In both of these trials, incidence of neutropenia, thrombocytopenia, and sensory neuropathy were significantly higher in the nongemcitabine treatment group. Clinicians and patients will have to balance the risk of these side effects against the significant but limited benefit offered by these regimens. Furthermore, it remains unknown if starting treatment in patients with advanced disease would be as beneficial when patients become symptomatic, as opposed to initiating therapy at the time of diagnosis of recurrent disease.

Although many patients experience recurrence with metastatic disease, a subset of patients manifest isolated local recurrence. It has been suggested that these patients have a longer median survival if their disease is amenable to repeat resection (26.0 vs. 10.8 months, $P = 0.0104$).¹⁸

The benefit of adjuvant chemoradiotherapy (CRT) for local recurrence remains controversial. Wilkowski et al.¹⁹ examined the efficacy of CRT in 18 patients with isolated local recurrence. Patients were treated with 45 Gy in 25 sessions of 1.8 Gy/day with simultaneous chemotherapy with 5-FU, 5-FU and gemcitabine, or 5-FU, gemcitabine, and cisplatin. Median survival from initiation of CRT was 17.5 months, and 12 of 18 patients had evidence of complete (37.5 %) or partial (37.5 %) remission, as evidenced by computed tomographic (CT) surveillance, although seven patients developed local tumor progression and 11 patients developed distant metastases (median progression-free survival, 14.7 and 11.0 months, respectively).

Habermehl et al.²⁰ recently conducted a retrospective analysis of 41 patients treated with CRT, repeat resection, and/or intraoperative radiotherapy for recurrent PDAC. They found that when repeat resection was feasible, median OS increased from 16.1 to 28.3 months after the initiation of CRT, although this was only possible in 15 % of patients. In addition, patients who received intraoperative radiotherapy had a significantly improved median OS versus those who did not ($P = 0.034$).

These studies suggest that CRT after local recurrence of PDAC is a feasible strategy; the survival time from the diagnosis of recurrent or metastatic disease is comparable to that of patients with unresectable disease, and the toxicity appears to be limited. An aggressive approach, however, may not benefit all patients, and it remains unclear whether CRT is beneficial in all patients with recurrent PDAC. These data are from a small, select group of patients, and data from larger randomized trials is lacking. Other palliative interventions, such as celiac plexus block, have been demonstrated to have a survival benefit similar to gemcitabine.^{21,22} In addition, biliary decompression and pain control also offer significant quality-of-life improvement.

CURRENT SURVEILLANCE STRATEGIES

The primary goal of surveillance after surgical resection is the timely detection of cancer recurrence—either local or distant—in order to offer patients further treatment options in the hope of curative intervention or at least improved survival. Additionally, surveillance presents an opportunity for the clinician to reassure a patient who may be consumed with a fear of cancer recurrence, which can be associated with anxiety, depression, a lower quality of life, and a higher degree of cancer-related symptoms.²³ Surveillance also allows for the introduction of noncurative palliative therapy to slow disease progression and prolong life in patients able to tolerate it, or the initiation of early hospice care when therapy would not be tolerated or is not indicated.

Current guidelines by NCCN and ESMO are the only tools that physicians and patients currently have to balance a high recurrence risk and aggressive treatment regimens in the face of minimal benefit (Table 1). The NCCN guidelines for follow-up after resection for

PDAC are based on expert opinion and recommend a history and physical examination every 3–6 months for 2 years.²⁴ Additionally, serum cancer-associated antigen 19-9 (CA19-9) levels and CT scan of the abdomen and pelvis are suggested at the same time intervals, but this recommendation is based on nonuniform expert opinion. After the initial 2 years, these tests are recommended annually.

The ESMO guidelines are based on the fact that there is no possibility for cure in the setting of local recurrence or metastasis, even if detected early, so the surveillance plan is recommended to be individualized to the patient in order to minimize emotional stress and economic burdens.²⁵ Additionally, if CA19-9 levels were elevated preoperatively, then the ESMO guidelines suggest measuring CA19-9 every 3 months for 2 years in addition to repeat CT scans of the abdomen and pelvis every 6 months.

These guidelines rely on expert opinion and low-level evidence because no studies have compared high- versus low-intensity surveillance in patients after surgical resection for PDAC. As a consequence, there is a wide variation in practice patterns between individuals and institutions.²⁶ Additionally, there are few published studies regarding the cost-effectiveness of these approaches. Tzeng et al.²⁷ have attempted to analyze the cost-effectiveness of postoperative surveillance through comparison of five different surveillance strategies: no scheduled surveillance, limited surveillance (routine clinical evaluation and CA19-9 levels with imaging triggered by symptoms) at 3- or 6-month intervals, and intensive surveillance (limited surveillance with routine CT scans and chest X-rays) at 3- or 6-month intervals. Utilizing a probabilistic model with data from 254 patients, the authors found that increasing the frequency and intensity of surveillance after operation increased cost substantially while offering no clinically significant survival benefit. On the basis of this analysis, the authors concluded that increasing the intensity of postoperative surveillance after curative resection beyond CA19-9 testing and clinical evaluation did not confer a significant survival benefit but did increase cost.

TUMOR MARKER SURVEILLANCE

The only biomarker used routinely in the surveillance of PDAC is CA19-9, a sialylated Lewis antigen originally identified in a colorectal carcinoma cell line.^{28,29} Expression of CA19-9 is dependent on the presence of Lewis blood group antigens; however, 5–10 % of white patients do not express CA19-9 as a result of a deficiency of fucosyltransferases that are necessary for the synthesis of the Lewis antigen.^{30–32} Expression is not limited to PDAC, however, and other conditions, such as hyperbilirubinemia, cirrhosis, cholangitis, and other malignancies, may lead to elevated levels.

Although CA19-9 has never been demonstrated to be effective as a screening test for PDAC as a result of its low positive predictive values (0.5–0.9 %), it has been used as a prognostic marker before and after surgical resection.^{33–35} Studies have demonstrated that CA19-9 is associated with a sensitivity of 70–90 % and specificity of 68–91 % for PDAC.^{36,37} Preoperative levels of ≥ 50 U/ml have been demonstrated to be predictive for recurrence after resection, while postoperative normalization of CA19-9 levels has been demonstrated to predict longer disease-free and median survival.^{38,39}

Given the high sensitivity and specificity of this test in monitoring disease and predicting recurrence, some have recommended that levels be measured every 3–6 months after surgical resection.²⁴ In fact, CA19-9 elevations have been demonstrated to precede clinical or radiologic evidence of recurrence by 2–6 months.⁴⁰ Despite this early warning, an elevated CA19-9 level without corresponding clinical, radiologic, or pathologic findings cannot be used to initiate further treatment.⁴¹ Taking these myriad factors together, Humphris et al.⁴² advocated that CA19-9 assessment at clinically relevant time points has utility because serum levels and trends over time may alter therapeutic choices in the future.

RADIOLOGIC SURVEILLANCE

The standard modality for radiologic surveillance after surgical resection is abdominal CT scan. Although CT scans may detect locally recurrent or metastatic disease, guidelines for the optimal frequency and strategy are not evidence based. Current NCCN guidelines, on the basis of expert opinion, recommend CT imaging every 3–6 months for 2 years, then yearly afterward. A retrospective analysis of data from the Surveillance, Epidemiology, and End Results (SEER)–Medicare database by Witkowski et al.⁴³ demonstrated that although the median number of imaging studies doubled between 1991 and 2005 (from three to six), there was no associated survival benefit in patients who underwent routine annual imaging within 5 years of resection.

Another analysis of SEER–Medicare data provides a comprehensive look at patterns of imaging after resection. Sheffield et al. analyzed postresection imaging patterns in 2,045 patients and demonstrated that CT scan utilization went from 20.9 % at initial follow-up (month 4) to 6.7 % by month 27, with no identifiable temporal pattern to suggest a routine, standardized method of surveillance.²⁶ Patients who received adjuvant therapy were more likely to undergo CT imaging during the course of their surveillance, as were patients who were treated in the later time period (2000–2005 vs. 1992–1999). Although this study demonstrated a wide variance in the utilization of imaging between patients, it was not able to differentiate routine surveillance versus diagnostic imaging.

One question not addressed by the previous studies is how imaging may affect diagnosis of recurrence. Tzeng et al. identified 216 patients (66.1 %) who developed postoperative recurrence during the course of a surveillance regimen that consisted of physical examination, CA19-9 measurement, chest radiograph, and abdominal CT scan every 3–4 months during the first 2 years after surgery, every 6 months until 5 years after surgery, and then annually thereafter.⁴⁴ They found that although median time to recurrence was not different between patients with symptomatic versus asymptomatic recurrence, survival in symptomatic patients was significantly decreased (5.1 vs. 13.0 months; $P < 0.001$). In this cohort, asymptomatic patients had a better overall performance status and lower median CA19-9 levels, and they were much more likely to receive treatment after recurrence was identified. A significant point of this study was the demonstration that a regularly scheduled surveillance regimen was able to detect asymptomatic recurrence in 54.6 % of patients, with the highest yield occurring in the first 2 years.

Another retrospective study examined outcomes in 139 patients who underwent resection for PDAC in a single tertiary referral center.⁴⁵ The surveillance regimen consisted of abdominal CT scan and serum CA19-9 level every 3 months for the first year, every 6 months for the second year, and annually thereafter. This study examined survival in groups stratified by postoperative surveillance regimen: those who followed up as recommended (14 %), those who followed up but not as recommended (59 %), and those who opted not to undergo any follow-up (27 %). The proportion of patients who opted for treatment of recurrent disease was similar in each group. The median survival of the groups was 16.6, 15.7, and 8.7 months, respectively. Although the authors suggest that more intensive follow-up may be associated with improved OS, this study was retrospective, limited in number, and from a single institution. There is thus an indication that routine follow-up may result in improved survival outcomes; however, no data clearly support this claim, and prospective trials are needed to clarify this potential benefit.

SUMMARY

Surveillance strategies for PDAC must take into account its high recurrence and low survival rates in the setting of limited therapeutic options for improved outcomes. Current guidelines for follow-up after surgical resection do not offer an evidence-based framework; therefore, strategies that are based on expert opinion remain the only approach. Although recent therapeutic advances have demonstrated the potential to improve survival in patients with metastatic PDAC, factors such as quality of life associated with treatment side effects, as well as the cost, both monetary and emotional, compared to the potential survival benefit, must also be accounted for.

The efficacy of treating clinically occult disease versus symptomatic disease remains unclear at this time. Additional prospective data will be required before it can be determined if postoperative imaging is warranted only in symptomatic patients. Prospective clinical data are also needed to identify the optimal surveillance strategy in the context of cost-effectiveness of improved survival and quality-of-life benefit. At present, the evidence, or lack thereof, would support a surveillance regimen along the lines of the ESMO guidelines until clear evidence emerges of the benefit of more intensive surveillance.

References

1. Siegel R, Ward E, Brawley O, Jemal A. Cancer statistics, 2011: the impact of eliminating socioeconomic and racial disparities on premature cancer deaths. *CA Cancer J Clin.* 2011; 61:212–36. [PubMed: 21685461]
2. Jemal A, Siegel R, Ward E, et al. Cancer statistics, 2008. *CA Cancer J Clin.* 2008; 58:71–96. [PubMed: 18287387]
3. Barugola G, Falconi M, Bettini R, et al. The determinant factors of recurrence following resection for ductal pancreatic cancer. *JOP.* 2007; 8:132–40. [PubMed: 17228145]
4. Griffin JF, Smalley SR, Jewell W, et al. Patterns of failure after curative resection of pancreatic carcinoma. *Cancer.* 1990; 66:56–61. [PubMed: 2354408]
5. Katz MH, Wang H, Fleming JB, et al. Long-term survival after multidisciplinary management of resected pancreatic adenocarcinoma. *Ann Surg Oncol.* 2009; 16:836–47. [PubMed: 19194760]
6. Cameron JL, Riall TS, Coleman J, Belcher KA. One thousand consecutive pancreaticoduodenectomies. *Ann Surg.* 2006; 244:10–5. [PubMed: 16794383]

7. Wagner M, Redaelli C, Lietz M, Seiler CA, Friess H, Buchler MW. Curative resection is the single most important factor determining outcome in patients with pancreatic adenocarcinoma. *Br J Surg*. 2004; 91:586–94. [PubMed: 15122610]
8. Howard TJ, Krug JE, Yu J, et al. A margin-negative R0 resection accomplished with minimal postoperative complications is the surgeon's contribution to long-term survival in pancreatic cancer. *J Gastrointest Surg*. 2006; 10:1338–45. [PubMed: 17175452]
9. Winter JM, Cameron JL, Campbell KA, et al. 1423 pancreaticoduodenectomies for pancreatic cancer: a single-institution experience. *J Gastrointest Surg*. 2006; 10:1199–210. [PubMed: 17114007]
10. Ozaki H, Hiraoka T, Mizumoto R, et al. The prognostic significance of lymph node metastasis and intrapancreatic perineural invasion in pancreatic cancer after curative resection. *Surg Today*. 1999; 29:16–22. [PubMed: 9934826]
11. Verbeke CS, Gladhaug IP. Resection margin involvement and tumour origin in pancreatic head cancer. *Br J Surg*. 2012; 99:1036–49. [PubMed: 22517199]
12. Van den Broeck A, Sergeant G, Ectors N, Van Steenberghe W, Aerts R, Topal B. Patterns of recurrence after curative resection of pancreatic ductal adenocarcinoma. *Eur J Surg Oncol*. 2009; 35:600–4. [PubMed: 19131205]
13. Iacobuzio-Donahue CA, Fu B, Yachida S, et al. *DPC4* gene status of the primary carcinoma correlates with patterns of failure in patients with pancreatic cancer. *J Clin Oncol*. 2009; 27:1806–13. [PubMed: 19273710]
14. Burris H, Storniolo AM. Assessing clinical benefit in the treatment of pancreas cancer: gemcitabine compared to 5-fluorouracil. *Eur J Cancer*. 1997; 33(Suppl 1):S18–22. [PubMed: 9166095]
15. Conroy T, Desseigne F, Ychou M, et al. FOLFIRINOX versus gemcitabine for metastatic pancreatic cancer. *N Engl J Med*. 2011; 364:1817–25. [PubMed: 21561347]
16. Von Hoff DD, Ramanathan RK, Borad MJ, et al. Gemcitabine plus nab-paclitaxel is an active regimen in patients with advanced pancreatic cancer: a phase I/II trial. *J Clin Oncol*. 2011; 29:4548–54. [PubMed: 21969517]
17. Von Hoff DD, Ervin TJ, Arena FP, et al. Randomized phase III study of weekly nab-paclitaxel plus gemcitabine versus gemcitabine alone in patients with metastatic adenocarcinoma of the pancreas (MPACT). *J Clin Oncol*. 2012;30. [PubMed: 23169502]
18. Strobel O, Hartwig W, Hackert T, et al. Re-resection for isolated local recurrence of pancreatic cancer is feasible, safe, and associated with encouraging survival. *Ann Surg Oncol*. 2013; 20(3): 964–72. [PubMed: 23233235]
19. Wilkowski R, Thoma M, Bruns C, Duhmke E, Heinemann V. Combined chemoradiotherapy for isolated local recurrence after primary resection of pancreatic cancer. *JOP*. 2006; 7:34–40. [PubMed: 16407616]
20. Habermehl D, Brecht IC, Bergmann F, et al. Chemoradiation in patients with isolated recurrent pancreatic cancer—therapeutic efficacy and probability of re-resection. *Radiat Oncol*. 2013; 8:27. [PubMed: 23369246]
21. Hwang SI, Kim HO, Son BH, Yoo CH, Kim H, Shin JH. Surgical palliation of unresectable pancreatic head cancer in elderly patients. *World J Gastroenterol*. 2009; 15:978–82. [PubMed: 19248198]
22. Staats PS, Hekmat H, Sauter P, Lillemoe K. The effects of alcohol celiac plexus block, pain, and mood on longevity in patients with unresectable pancreatic cancer: a double-blind, randomized, placebo-controlled study. *Pain Med*. 2001; 2:28–34. [PubMed: 15102315]
23. Petzel MQ, Parker NH, Valentine AD, et al. Fear of cancer recurrence after curative pancreatectomy: a cross-sectional study in survivors of pancreatic and periampullary tumors. *Ann Surg Oncol*. 2012; 19:4078–84. [PubMed: 22875648]
24. Tempero MA, Arnoletti JP, Behrman S, et al. Pancreatic adenocarcinoma. *J Natl Compr Cancer Netw*. 2010; 8:972–1017.
25. Cascinu S, Falconi M, Valentini V, Jelic S. Pancreatic cancer: ESMO clinical practice guidelines for diagnosis, treatment and follow-up. *Ann Oncol*. 2010; 21(Suppl 5):v55–8. [PubMed: 20555103]

26. Sheffield KM, Crowell KT, Lin YL, Djukom C, Goodwin JS, Riall TS. Surveillance of pancreatic cancer patients after surgical resection. *Ann Surg Oncol.* 2012; 19:1670–7. [PubMed: 22143577]
27. Tzeng CW, Abbott DE, Cantor SB, et al. Frequency and intensity of postoperative surveillance after curative treatment of pancreatic cancer: a cost-effectiveness analysis. *Ann Surg Oncol.* 2013; 20:2197–203. [PubMed: 23408126]
28. Winter JM, Yeo CJ, Brody JR. Diagnostic, prognostic, and predictive biomarkers in pancreatic cancer. *J Surg Oncol.* 2013; 107:15–22. [PubMed: 22729569]
29. Koprowski H, Steplewski Z, Mitchell K, Herlyn M, Herlyn D, Fuhrer P. Colorectal carcinoma antigens detected by hybridoma antibodies. *Somatic Cell Genet.* 1979; 5:957–71. [PubMed: 94699]
30. Berger AC, Garcia M Jr, Hoffman JP, et al. Postresection CA 19-9 predicts overall survival in patients with pancreatic cancer treated with adjuvant chemoradiation: a prospective validation by RTOG 9704. *J Clin Oncol.* 2008; 26:5918–22. [PubMed: 19029412]
31. Lamerz R. Role of tumour markers, cytogenetics. *Ann Oncol.* 1999; 10(Suppl 4):145–9. [PubMed: 10436809]
32. Tempero MA, Uchida E, Takasaki H, Burnett DA, Steplewski Z, Pour PM. Relationship of carbohydrate antigen 19-9 and Lewis antigens in pancreatic cancer. *Cancer Res.* 1987; 47:5501–3. [PubMed: 3308077]
33. Satake K, Takeuchi T. Comparison of CA19-9 with other tumor markers in the diagnosis of cancer of the pancreas. *Pancreas.* 1994; 9:720–4. [PubMed: 7846015]
34. Chang CY, Huang SP, Chiu HM, Lee YC, Chen MF, Lin JT. Low efficacy of serum levels of CA 19-9 in prediction of malignant diseases in asymptomatic population in Taiwan. *Hepatogastroenterology.* 2006; 53:1–4. [PubMed: 16506366]
35. Kim JE, Lee KT, Lee JK, Paik SW, Rhee JC, Choi KW. Clinical usefulness of carbohydrate antigen 19-9 as a screening test for pancreatic cancer in an asymptomatic population. *J Gastroenterol Hepatol.* 2004; 19:182–6. [PubMed: 14731128]
36. Goonetilleke KS, Siriwardena AK. Systematic review of carbohydrate antigen (CA 19-9) as a biochemical marker in the diagnosis of pancreatic cancer. *Eur J Surg Oncol.* 2007; 33:266–70. [PubMed: 17097848]
37. Steinberg W. The clinical utility of the CA 19-9 tumor-associated antigen. *Am J Gastroenterol.* 1990; 85:350–5. [PubMed: 2183589]
38. Kang CM, Kim JY, Choi GH, et al. The use of adjusted preoperative CA 19-9 to predict the recurrence of resectable pancreatic cancer. *J Surg Res.* 2007; 140:31–5. [PubMed: 17418869]
39. Montgomery RC, Hoffman JP, Riley LB, Rogatko A, Ridge JA, Eisenberg BL. Prediction of recurrence and survival by post-resection CA 19-9 values in patients with adenocarcinoma of the pancreas. *Ann Surg Oncol.* 1997; 4:551–6. [PubMed: 9367020]
40. Ballehaninna UK, Chamberlain RS. The clinical utility of serum CA 19-9 in the diagnosis, prognosis and management of pancreatic adenocarcinoma: an evidence based appraisal. *J Gastrointest Oncol.* 2012; 3:105–19. [PubMed: 22811878]
41. Locker GY, Hamilton S, Harris J, et al. ASCO 2006 update of recommendations for the use of tumor markers in gastrointestinal cancer. *J Clin Oncol.* 2006; 24:5313–27. [PubMed: 17060676]
42. Humphris JL, Chang DK, Johns AL, et al. The prognostic and predictive value of serum CA19.9 in pancreatic cancer. *Ann Oncol.* 2012; 23:1713–22. [PubMed: 22241899]
43. Witkowski ER, Smith JK, Ragulin-Coyne E, Ng SC, Shah SA, Tseng JF. Is it worth looking? Abdominal imaging after pancreatic cancer resection: a national study. *J Gastrointest Surg.* 2012; 16:121–8. [PubMed: 21972054]
44. Tzeng CW, Fleming JB, Lee JE, et al. Yield of clinical and radiographic surveillance in patients with resected pancreatic adenocarcinoma following multimodal therapy. *HPB (Oxford).* 2012; 14:365–72. [PubMed: 22568412]
45. Shabahang, M.; Marchessault, M.; Luh, J., et al. The effect of close postoperative follow-up on survival outcome of patients with pancreatic cancer (abstract 262). Presented at: Gastrointestinal Cancers Symposium; 2010. Available at: <http://meetinglibrary.asco.org/content/2342-72>

TABLE 1

Current surveillance guidelines after resection for PDAC

Society	Recommendation	Evidence level
National Comprehensive Cancer Network	Clinical evaluation every 3–6 months for 2 years, then annually CA19-9, CT scan every 3–6 months for 2 years, then annually	Low-level expert opinion (uniform) Expert opinion (nonuniform)
European Society of Medical Oncology	Follow-up schedule discussed with patient, designed to avoid emotional stress and economic burden for the patient If CA19-9 is elevated before surgery, then reassess every 3 months for 2 years Abdominal CT scan every 6 months	Low level Expert opinion Expert opinion

PDAC pancreatic adenocarcinoma, CA carbohydrate antigen, CT computed tomography