OA Surgery
Open Access

Research study

Upper GI Surgery

Predictors of mortality following pancreaticoduodenectomy for periampullary cancer

A Annamalai[1]*, VR Kakarla[2], K Nandipati[3]

Abstract

Introduction

Pancreaticoduodenectomy is associated with significant post-operative morbidity and mortality. Identifying the pre-operative factors that increase the risk of post-operative morbidity might improve patient selection and risk stratification, and may lead to better outcomes. The aim of this article was to evaluate the predictors of mortality following pancreaticoduodenectomy for periampullary cancer.

Materials and Methods

Using the American College of Surgeons–National Surgical Quality Improvement Project's participant-use file, we identified all patients who underwent pancreaticoduodenectomy (Whipple) for periampullary cancer at the 240 participating hospitals. Demographic, clinical and intra-operative variables and 30-day morbidity and mortality were collected in standardised fashion.

Results

From the 2005 to 2008 databases, we identified 3072 patients who underwent pancreaticoduodenectomy. The 30-day mortality following Whipple was 3% (92/3072). Pre-operative factors leading to increased risk of mortality included: age >55 years (OR 2.65, P = 0.005), non-insulin dependent diabetes (NIDDM) (OR 1.7, P = 0.0423), dyspnoea at rest (OR 7.14, P = 0.013) and with moderate exercise (OR 2.4, P = 0.0037), chronic obstructive pulmonary disease (COPD) (OR 2.8, P = 0057), ascites (OR 4.3, P = 0.0411), congestive heart failure (CHF) (OR 33.8, P < 0.0001), hypertension (OR 1.8, P = 0.0076) and acute renal failure (OR 16.53, P = 0.0123); albumin < 2.5, elevated blood urea nitrogen (BUN), partial thromboplastin time (PTT) and international normalized ratio (INR). Peri-operative and post-operative factors that increase the risk of mortality were operative time, organ space infection, pneumonia, septic shock, unplanned intubation, renal failure and myocardial infarction.

Conclusion

Recognising the risk factors pre-operatively may help guide physicians in the management of these patients. Optimising patient selection and risk stratification is crucial in these patients and will likely lead to improved outcomes and quality of life.

Introduction

Periampullary cancer is the fourth leading cause of cancer-related mortality in the United States accounting for 12–15 cases per 100,000. Pancreaticoduodenectomy remains to be the best option for a cure and improving survival. However, it is one of the most difficult operations to perform and is associated with significant morbidity and mortality. Post-operative mortality has been shown to range from 3% to 5% in high-volume centres to 40% in low-volume centres[1]. The majority of these studies were based on retrospective data from single institutions, and as such, these results may not apply to all health care institutions. There have been a few studies in the recent past showing the influence of peri-operative risk factors of morbidity and mortality, but these have not been well characterised to the nation as a whole[2–5].

National Surgical Quality Improvement Program (NSQIP), originally designed by the Veterans Affairs health care system allows us to compare institutions nationwide in a risk-adjusted manner[6–8]. Over the past several years, the American College of Surgery has developed a programme that now includes over a hundred private health care systems that actively participate in the NSQIP. Utilising this database, peri-operative variables of surgical risk can be identified that facilitate a comparative assessment between multiple institutions.

The goal of our study is to determine the risk-adjusted predictors of morbidity and mortality for those undergoing pancreaticoduodenectomy for periampullary cancer in NSQIP database. Identification of risk-adjusted pre-operative factors that will increase post-operative complications may allow health care facilities to better select patients and stratify risks to decrease morbidity and improve survival.

Materials and Methods

This work conforms to the values laid down in the Declaration of Helsinki (1964). The protocol of this study has been approved by the relevant ethical committee related to our institution in which it was performed. All subjects gave full informed consent to participate in this study.

* Corresponding author
Email: alagappan.annamalai@cshs.org

[1] Cedars-Sinai Medical Center, Department of Abdominal Transplant and Hepatopancreaticobiliary Surgery, Los Angeles, 90048, CA, USA
[2] University of Illinois, Department of Surgery, Chicago, 60612, USA
[3] Emory University, Department of Surgery, Atlanta, 30322, USA

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

FOR CITATION PURPOSES: *Annamalai A, Kakarla VR, Nandipati K.* Predictors of mortality following pancreaticoduodenectomy for periampullary cancer. OA Surgery 2014 Jan 18;2(1):2.

OA Surgery
Open Access

The American College of Surgeons NSQIP (ACS–NSQIP is the first nationally validated, risk-adjusted, outcomes-based programme to measure and improve the quality of surgical care. ACS-NSQIP collects data on 136 variables from 211 participating hospitals, including pre-operative risk factors, intra-operative variables, and 30-day post-operative mortality and morbidity outcomes for patients undergoing major surgical procedures in both the inpatient and outpatient setting.

For this study ACS–NSQIP participating user files from 2005 to 2008 were used. Patients were selected from these database files based on current procedural terminology (CPT) codes 48150 (pancreaticoduodenectomy) and 48153 (pancreaticoduodenectomy with pylorus preservation). Patients who underwent a pancreaticoduodenectomy without pancreaticojejunostomy (48152, 48154) were not included in the study. With International Classification of Diseases (ICD) codes, only the patients with the diagnosis of carcinoma of the pancreas (ICD-9 157.0 – 17.9), Ampulla of Vater (156.2), duodenum (152.0) or bile duct (156.1) were selected. Patients with benign diseases of the pancreas and had pancreaticoduodectomy for other reasons were excluded from the study. These patients are further divided into two groups; mortality and survivor groups and were compared with multiple variables.

All of the following pre-operative patient variables were collected, including: demographics (age, sex and BMI), 29 pre-operative-associated co-morbidities, 13 pre-operative lab values, intra-operative (ASA classification, operative time, intra-operative occurrences, blood transfusions and operative time) and 30-day post-operative morbidity occurrences (14 post-operative complications including wound complications), re-operative occurrences, length of stay, and 30-day post-operative mortality (death from any cause inside or outside of the hospital within 30 days of operation). Factors with no occurrences were not included in the analysis.

Statistical analysis

Univariate analysis was performed for all pre-, peri- and post-operative variables. Age, pre-operative albumin and total bilirubin levels were further subdivided into groups. Chi-square and Fisher's *t*-test were used for analysis. A forward conditional stepwise binary logistic regression was conducted to find the best statistical predictive model of patient Whipple (WP) surgery survival. The binary logistic regression was utilised because the criterion was dichotomous: WP survival or WP death. The strength of logistic regression predictors is usually tested with the Wald statistic. Age, total operation time, number of times on ventilator over 48 hours and estimated probability of mortality were all negative predictors of WP survival. Graph pad and SPSS software was used for statistical analysis. *P*-value <0.05 is considered statistically significant.

Results

By using the selection method described above with ICD codes for periampullary cancer and CPT code for WP's procedure and inclusion and exclusion criteria, a total of 3072 patients were identified from the ACS–NSQIP database from 2005 to 2008. Males and females are almost evenly distributed with a mean age of 65.6 years. Overall mortality rate of 3% was noted in these patients (92 out of 3072). These patients are divided based on the outcome into mortality group (MG) and survival group (SG) and 2980 patients were included in the SG group and 92 in MG. Analysis between groups were carried out as follows.

Pre-operative variables

Patients in SG are significantly younger in age compared with the MG (65.5 vs. 71.9; *P* <0.0001). On subanalysis of age, patients aged above 55 years have a statistically higher chance of mortality compared with the patients aged below 55 years. No significant difference was noted in other patient factors such as sex, height, weight and BMI (Tables 1–3).

In pre-operative co-morbidities patients in MG compared with the SG have significantly higher incidence of NIDDM (390 (13.1%) vs. 19 (20.65%), *P* = 0.0423, OR 1.73), dyspnoea at rest (14 (0.5%) vs. 3 (3.26%), *P* = 0.013, OR 7.14), dyspnoea at moderate exertion (223 (7.5%) vs. 15 (16.3%), *P* = 0.0037, OR 2.4), COPD (123 (4.1%) vs. 10 (10.87%), *P* = 0.0057, OR 2.8), ascites (23 (0.8%) vs. 3 (3.26%), *P* = 0.0411, OR 4.33), CHF (4 (0.1%) vs. 4 (4.35%), *P* < 0.0001, OR 33.8), hypertension (1616 (54.2%) vs. 63 (68.48%), *P* = 0.0076, OR 1.8), and pre-operative acute

Table 1 Sex, age and BMI variables

	Whipple – survivors	Whipple – deaths	*P*-value
N	2980	92	
Female	1420 (47.7%)	49 (53.26%)	0.2918
Male	1560 (52.3%)	43 (46.74%)	0.2918
Age	65.5 years	71.88 years	0.0001
< 55 years	602 (20.2%)	8 (8.7%)	0.005
> 55 years	2378 (79.8%)	84 (91.3%)	0.005
BMI	29	30.3	

BMI, body mass index.

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

FOR CITATION PURPOSES: *Annamalai A, Kakarla VR, Nandipati K.* Predictors of mortality following pancreaticoduodenectomy for periampullary cancer. OA Surgery 2014 Jan 18;2(1):2.

OA Surgery
Open Access

Research study

renal failure (4 (0.1%) vs. 2 (2.17%), $P = 0.0123$, OR 16.5). MG is also noted to have significantly high number of emergency cases (23 (0.8%) vs. 2 (2.17%), $P = 0.0371$, OR 2.85) and also patients with disseminated cancer (53 (1.7%) vs. 5 (5.43%), P=0.0284, OR 3.17). No significant difference was noted in the incidence of insulin dependent diabetes (IDDM), history of smoking, history of alcohol abuse, myocardial infarction, angina, previous percutaneous coronary interventions or cardiac surgery, use of steroids, bleeding disease and history of chemotherapy or radiation in between the two groups. MG has a significantly higher number of patients with ASA class 3 and class 4, and SG has significantly higher number of ASA class 2 patients.

Post-operative complications

In MG there is significantly high incidence of most of the post-operative complications that are available in NSQIP data, except the incidence of urinary tract infections and overall incidence of sepsis (Table 2). Also in MG, a significantly higher number of patients underwent re-operative intervention (200 (6.7%) vs. 44 (47.83%), $P < 0.0001$). No significant difference was noted between two groups in the occurrence of superficial or deep surgical site infections or wound disruptions. But a significantly higher incidence of organ space surgical infection was noted in the MG group (291 (9.7%) vs. 22 (23.91%), $P < 0.0001$) which may be suggestive of intra-abdominal abscesses or leaks. In MG the duration of the operative procedure was noted to be significantly higher when compared with SG (418 min vs. 382 min; P 0.005). There is no difference noted in length of stay between the two groups (Tables 4 and 5).

On logistic regression analysis, age, operative time, failure to wean, septic shock and cardiac arrest ($P < 0.05$) are the only factors shown to have significant association with

Table 2 Pre-operative variables

	Survivors	Deaths	*P*-value	Odds ratio
N	2980	92		
Hypertension	161 (54.2%)	63 (68.48%)	0.0076	1.8336
Weight loss	668 (22.4%)	23 (25%)	0.5287	
Smoking	625 (21%)	19 (20.65%)	1	
NIDDM	390 (13.1%)	19 (20.65%)	0.0423	1.7285
IDDM	313 (10.5%)	9 (9.78%)	1	
Dyspnoea at rest	14 (0.5%)	3 (3.26%)	0.013	7.1413
Dyspnoea at moderate exertion	223 (7.5%)	15 (16.3%)	0.0037	2.4084
COPD	123 (4.1%)	10 (10.87%)	0.0057	2.8326
Ventilator dependent	5 (0.2%)	0	0.1411	
CHF	4 (0.1%)	4 (4.35%)	0.0001	33.8182
Angina	13 (0.4%)	1 (1.09%)	0.3473	
MI	10 (0.3%)	1 (1.09%)	0.2847	
Previous coronary interventions	202 (6.8%)	10 (10.87%)	0.1397	
Previous cardiac surgery	181 (6.1%)	9 (9.78%)	0.1805	
Acute renal failure	4 (0.1%)	2 (2.17%)	0.0123	16.5333
Hemo dialysis	8 (0.3%)	1 (1.09%)	0.2397	
Bleeding disorders	62 (2.1%)	3 (3.26%)	0.444	
Ascites	23 (0.8%)	3 (3.26%)	0.0411	4.337
Disseminated cancer	53 (1.8%)	5 (5.43%)	0.0284	3.1739
Chemotherapy	46 (1.5%)	3 (3.26%)	0.1798	
Radiotherapy	79 (2.7%)	5 (5.43%)	0.105	
Emergency	23 (0.8%)	2 (2.17%)	0.0371	2.857

NIDDM, non-insulin dependent diabetes; IDDM, insulin dependent diabetes; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; MI, myocardial infarction.

FOR CITATION PURPOSES: *Annamalai A, Kakarla VR, Nandipati K.* Predictors of mortality following pancreaticoduodenectomy for periampullary cancer. OA Surgery 2014 Jan 18;2(1):2.

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

OA Surgery
Open Access

Table 3 ASA classification				
	Survivors	Deaths	*P*-value	Odds ratio
N	2980	92		
Class 1	36 (1.2%)	0	0.2935	
Class 2	870 (29.2%)	10 (10.87%)	(0.0001)	
Class 3	1926 (64.6%)	70 (76.09%)	0.026	1.7412
Class 4	146 (4.9%)	11 (11.96%)	0.0064	2.6361

the mortality. The coefficients indicated that the number of cardiac arrests requiring cardiopulmonary resuscitation (CPR) was the strongest predictor in the final model, $\beta = -5.97$, $P < 0.001$. Given the coding of the criterion (0 = WP death, 1 = WP survivor), the negative coefficient indicates that individuals with fewer cardiac arrests requiring CPR were more likely to survive. The second strongest predictor in the final model was the number of septic shock occurrences, $\beta = -3.11$, $P < 0.001$.

Discussion

Periampullary cancer is still among the leading causes of cancer-related deaths and remains an area of continued research. It has been reported that in large volume institutions, the mortality rate associated with pancreaticoduodenectomy is 3–5%. In a study including over 7000 Medicare patients the mortality rate was reported to be 10%[9]. This was similar to the study done by the VA health care system (total of 462 patients in the study group)[10], which reported a mortality rate of 9.3%. This study also determined pre-operative patient factors that affected post-operative mortality using NSQIP data collected from VA hospitals. This study was done only including VA hospitals and thus included >95% of men. Our study aimed at determining pre-operative patient variables and post-operative complications in a risk-adjusted multi-institutional manner using ACS–NSQIP data from over 200 nationwide hospitals. The mortality rate after pancreaticoduodenectomy in our study was 3%, comparable to the rate at high-volume hospitals[11].

Table 4 Post-operative complications			
	Survivors	Deaths	*P*-value
N	2980	92	
Pneumonia	146 (4.9%)	28 (30.43%)	0.0001
Unplanned intubation	118 (3.9%)	58 (63.04%)	0.0001
On ventilator for >48 h	154 (5.1%)	42 (45.65%)	0.0001
Pulmonary embolism	29 (1%)	4 (4.35%)	0.0159
Cardiac arrest	5 (0.2%)	30 (32.61%)	0.0001
MI	5 (0.2%)	3 (3.26%)	0.0013
Renal failure	15 (05%)	5 (5.43%)	0.0002
Acute renal failure	19 (0.6%)	19 (20.65%)	0.0001
Urinary tract infection	170 (5.7%)	3 (3.26%)	0.487
Deep vein thrombosis	61 (2%)	4 (4.35%0	0.0435
Bleeding	40 (1.3%)	9 (9.78%)	0.0001
Sepsis	357 (12%)	13 (14.13%)	0.5152
Septic shock	126 (4.2%)	50 (54.35%)	0.0001
Return to OR	200 (6.7%)	44 (47.83%)	0.0001

MI, myocardial infarction; OR, odds ratio.

In our study, the pre-operative factors leading to increased risk of mortality included: age >55 years, ASA class 3 or 4, dyspnoea at rest and with moderate exercise, NIDDM, COPD, CHF, hypertension, albumin <2.5 and ascites. Peri- and post-operative factors that increase the risk of mortality were operative time, organ space infection, pneumonia, septic shock, unplanned intubation, renal failure and myocardial infarction.

Age has been shown to be an independent predictor of mortality with steady increases for every successive decade after the age of 50. Our data were consistent with this finding of other multiple studies reported in the literature. Although there is in an increase in mortality with age, the benefit of pancreaticoduodenectomy even in patients over the age of 70 continues to show overall higher chance of survival compared with non-operative management[12,13].

There have been multiple studies in the past clearly demonstrating increasing morbidity and mortality rates with increasing ASA class associated with a variety of surgical procedures[14]. In our study, univariate analysis showed that ASA class 3 and class 4 were associated with a significantly higher risk of mortality. Patients in these higher ASA classes often have one of several comorbidities including COPD, CHF and symptoms of dyspnoea with moderate activity or at rest.

Albumin is a marker of nutritional status and has been found to be a significant predictor of outcome following several surgical procedures. Albumin levels below 3.0 are considered to increase post-operative morbidity and mortality[15]. In our study albumin

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

FOR CITATION PURPOSES: *Annamalai A, Kakarla VR, Nandipati K.* Predictors of mortality following pancreaticoduodenectomy for periampullary cancer. OA Surgery 2014 Jan 18;2(1):2.

OA Surgery
Open Access

Table 5 Post-operative wound complications			
	Survivors	Deaths	*P*-value
N	2980	92	
Superficial	322 (10.8%)	6 (6.52%)	0.1677
Deep	68 (2.3%)	3 (3.26%)	0.4708
Organ space infection	291 (9.7%)	22 (23.91%)	0.0001
Wound disruption	61 (2%)	3 (3.26%)	0.44

levels less than 2.5 correlated with increased mortality rates. In these cases, patients undergoing pancreaticoduodenectomy for cancer, low albumin levels may be secondary to long-term poor nutritional status or secondary to cancer-related cachexia. Similarly, we found that the presence of ascities was associated with a worse outcome. This is likely to be related to poor liver function and poor overall nutritional status.

Increased bilirubin levels may be a marker of more advanced disease and associated higher mortality. It was thought that this elevation in bilirubin was a causative factor of post-operative morbidity including organ dysfunction and haemorrhage. In our study, we did not find any association between bilirubin levels up to 16 mg/dL and mortality. From the available data it was not possible to identify the subgroup which underwent pre-operative biliary drainage. In many recent studies it has been shown that biliary stent placement does not improve outcome and may actually increase morbidity, unless total bilirubin levels are >20[16].

Another aspect of our study was that a total of 25 patients had emergency operations of whom 2 died post-operatively and 58 patients had pancreaticoduodenectomy for 'disseminated disease'. Review of NSQIP data is limited in its ability to clearly define what the meaning of disseminated disease means. This reflects impressions found in the final pathology reports regarding extent or diffuse pattern of disease involvement of margins or lymph nodes. Also, the ability to determine the exact meaning of emergency surgery is not possible. Lieberman et al.[17] showed a significant increase in mortality for urgent operations (16.6% vs. 10.4%). Based on these findings, it is important to use pre-operative findings, including radiological, ultrasound and biopsy results to direct surgical intervention and the role of diagnostic laparoscopy. If these findings are suggestive of extensive disease the management algorithm may differ and include pre-operative chemotherapy and/or radiation therapy.

In our logistic regression analysis, length of operative time is significantly associated with post-operative mortality. Similarly, VA study also reported that longer operative time was associated with significantly high mortality. Lack of experience, technical factors and intra-operative complication could have been the few of several reasons associated with length of the operative time. This observation also supports that these operations should be performed by an experienced surgeon at high-volume centres[18]. Institution volume and outcome after pancreaticoduodenectomy has been investigated several times over the past. Several authors, including Lieberman et al.[17] and Begg et al.[19], have clearly demonstrated decreased hospital mortality in high-volume institutions. Our study did not address outcome versus hospital volume. The NSQIP database randomly assesses cases in a non-biased manner from each hospital. This mixed case log attained by NSQIP is an extremely beneficial way in studying outcomes and complication rates after complex procedures that are not done in large volumes, not done in a standardised fashion and not having standardised pre-or post-operative care.

Post-operative morbidity has been demonstrated to be a cause of increased 30-day mortality after many common surgeries. Septic shock and failure to wean from the ventilator are two important post-operative variables significantly associated with increased mortality in our study. Sepsis and septic shock have been the leading cause of morbidity and mortality following several intra-abdominal operations. Septic shock in the post-operative period can result from pneumonia and organ space infection. Organ space infection is likely to be secondary to anastamotic leak or intra-abdominal abscess development. Prevention of sepsis and aggressive management septic shock might improve outcome in these patients. Irrespective of aetiology, septic shock also delays the weaning from the ventilator, which in turn acts as an independent predictor of mortality. It is influenced by several pre-, intra- and post-operative factors. Post-operative failure of extubation, unplanned re-intubation, renal failure, pneumonia, sepsis and myocardial infarction can lead to failure to wean from the ventilator. Adequate pre-operative optimisation of chronic medical conditions, such as COPD, diabetes and CHF combined with aggressive peri- and post-operative management of patient comorbidities might reduce the post-operative mortality by decreasing post-operative complications.

Inherent to the review of NSQIP databases regarding pancreaticoduodenectomy, there are limitations in determining the exact technical aspects of how the operation was performed and the nature of peri-operative management. It is not known whether patients had pyloric

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

OA Surgery
Open Access

Research study

preservation, and what type of anastamosis was created. Also, it is not known whether patients received specific peri-operative medications or procedures, including ocreotide or other interventional procedures such as biliary decompression. Differences among multiple hospitals and each surgeon preferences may affect overall complication rates.

An enormous benefit of NSQIP is its ability to provide a set of predictors of mortality to perform risk-adjusted models that will allow comparison with institutions across the nation performing pancreaticoduodenectomy. This will lead to overall improved performance of this complex surgery.

Conclusion

Our study identified a number of variables that significantly influence the outcomes of patients undergoing pancreaticoduodenectomy for periampullary cancer. Recognising these risk factors pre-operatively may help guide physicians in the management of these patients. Optimising patient selection and risk stratification is crucial in these patients and will likely lead to improved outcomes and quality of life.

Abbreviations list

ACS–NSQIP, American College of Surgeons–National Surgical Quality Improvement Project; CPT, current procedural terminology; ICD, International Classification of Diseases; MG, mortality group; SG, survival group; WP, Whipple.

Acknowledgement

This research has been presented at the IHPBA, May 2010 conference.

References

1. Lieberman MD, Kilburn H, Lindsey M, Brennan MF. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. Ann Surg. 1995 Nov;222(5):638–45.
2. Sohn TA, Yeo CJ, Cameron JL, Lillemoe KD, Talamini MA, Hruban RH, et al. Should pancreaticoduodenectomy be performed in octogenarians? J Gastrointest Surg. 1998 May–Jun;2(3):207–16.
3. Barnett SA, Collier NA. Pancreaticoduodenectomy: does preoperative biliary drainage, method of pancreatic reconstruction or age influence perioperative outcome? A retrospective study of 104 consecutive cases. ANZ J Surg. 2006 Jul;76(7):563–8.
4. Winter JM, Cameron JL, Yeo CJ, Alao B, Lillemoe KD, Campbell KA, et al. Biochemical markers predict morbidity and mortality after pancreaticoduodenectomy. J Am Coll Surg. 2007 May;204(5):1029–36.
5. Williams TK, Rosato EL, Kennedy EP, Chojnacki KA, Andrel J, Hyslop T, et al. Impact of obesity on perioperative morbidity and mortality after pancreaticoduodenectomy. J Am Coll Surg. 2009 Feb;208(2):210–7.
6. Khuri SF. The NSQIP: a new frontier in surgery. Surgery 2005 Nov;138(5):837–43.
7. Fink AS, Campbell DA Jr, Mentzer RM Jr, Henderson WG, Daley J, Bannister J, et al. The National Surgical Quality Improvement Program in non-veterans administration hospitals: initial demonstration of feasibility. Ann Surg. 2002 Sep;236(3):344–53.
8. Khuri SF, Daley J, Henderson W, Hur K, Demakis J, Aust JB, et al. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. National VA Surgical Quality Improvement Program. Ann Surg. 1998 Oct;228(4):491–507.
9. Birkmeyer JD, Warshaw AL, Finlayson SR, Grove MR, Tosteson AN. Relationship between hospital volume and late survival after pancreaticoduodenectomy. Surgery. 1999 Aug;126(2):178–83.
10. Billingsley KG, Hur K, Henderson WG, Daley J, Khuri SF, Bell RH Jr. Outcome after pancreaticoduodenectomy for periampullary cancer: an analysis from theVeterans Affairs National Surgical Quality Improvement Program. J Gastrointest Surg. 2003 May–Jun;7(4):484–91.
11. Teh SH, Diggs BS, Deveney CW, Sheppard BC. Patient and hospital characteristics on the variance of perioperative outcomes for pancreatic resection in the United States: a plea for outcome-based and not volume-based referral guidelines. Arch Surg. 2009 Aug;144(8):713–21.
12. Ouaïssi M, Sielezneff I, Pirrò N, Merad A, Loundou A, Chaix JB, et al. Pancreatic cancer and pancreaticoduodenectomy in elderly patient: morbidity and mortality are increased. Is it the real life? Hepatogastroenterology. 2008 Nov–Dec;55(88):2242–6.
13. Tani M, Kawai M, Hirono S, Ina S, Miyazawa M, Nishioka R, et al. A pancreaticoduodenectomy is acceptable for periampullary tumors in the elderly, even in patients over 80 years of age. J Hepatobiliary Pancreat Surg. 2009;16(5):675–80.
14. Hightower CE, Riedel BJ, Feig BW, Morris GS, Ensor JE Jr, Woodruff VD, et al. A pilot study evaluating predictors of postoperative outcomes after major abdominal surgery: physiological capacity compared with the ASA physical status classification system. Br J Anaesth. 2010 Apr;104(4):465–71.
15. Winter JM, Cameron JL, Yeo CJ, Alao B, Lillemoe KD, Campbell KA, et al. Biochemical markers predict morbidity and mortality after pancreaticoduodenectomy. J Am Coll Surg. 2007 May;204(5):1029–36.
16. van der Gaag NA, Rauws EA, van Eijck CH, Bruno MJ, van der Harst E, Kubben FJ, et al. Preoperative biliary drainage for cancer of the head of the pancreas. N Engl J Med. 2010 Jan;362(2):W129–37.
17. Lieberman MD, Kilburn H, Lindsey M, Brennan MF. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection formalignancy. Ann Surg. 1995 Nov;222(5):638–45.
18. Stephens J, Kuhn J, O'Brien J, Preskitt J, Derrick H, Fisher T, et al. Surgical morbidity, mortality, and long-term survival in patients with peripancreatic cancer following pancreaticoduodenectomy. Am J Surg. 1997 Dec;174(6):600–3.
19. Begg CB, Cramer LD, Hoskins WJ, Brennan MF. Impact of hospital volume on operative mortality for major cancer surgery. JAMA. 1998 Nov;280(20):1747–51.

FOR CITATION PURPOSES: *Annamalai A, Kakarla VR, Nandipati K.* Predictors of mortality following pancreaticoduodenectomy for periampullary cancer. OA Surgery 2014 Jan 18;2(1):2.

Competing interests: none declared. Conflict of interests: none declared.
All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.
All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.