

ORIGINAL PAPER

Survival Benefits and Disparities in Adjuvant Radiation Therapy for Patients with Pancreatic Cancer

Mirza Zain Baig¹, Alexandra Filkins², Muhammad Khan³, Muhammad Wasif Saif^{3*}, Hassan Aziz⁴

¹Department of Surgery, Rudy Ruggles Biomedical Research Institute, Nuvance Health, USA

²Department of Surgery, University of Southern California, Keck School of Medicine, CA, USA

³Department of Medical Oncology, Northwell Health Cancer Institute, Donald and Barbara Zucker School of Medicine at Hofstra and Feinstein Institute for Medical Research, USA

⁴Department of Surgery, New York Medical College, Westchester Medical Center Health Network, Valhalla

ABSTRACT

Background The effects of adjuvant radiation therapy on pancreatic cancer outcomes after resection are not well defined in the literature. **Methods** We abstracted data from the Surveillance, Epidemiology, and End Result (SEER) database to explore the impact of adjuvant radiation on cancer-specific survival in pancreatic cancer patients who received surgical resection. **Results** A total of 10,224 patients met our inclusion criteria with 6768 (66.2%) patients treated with surgery only and 3456 (33.8%) treated with surgery plus adjuvant radiation. Surgery followed by adjuvant radiation was associated with significantly improved survival (HR: 0.753, CI: 0.718–0.789, $p < 0.001$). Additionally, female gender and married status were both independently associated with better survival ($p < 0.05$), while advanced age, Caucasian race, higher TNM stage, and higher grade had worse survival outcomes ($p < 0.05$). Asian and Spanish-Hispanic-Latino patients were less likely to receive adjuvant radiotherapy ($p < 0.05$). **Conclusion** Adjuvant radiation was associated with significantly improved survival after resection for pancreatic cancer. There are significant differences in the patient populations who receive adjuvant radiation.

INTRODUCTION

In the year 2020, about 57,600 people will be diagnosed with pancreatic cancer and approximately 47,050 people will die of this devastating disease. Over the last several decades, the survival rates among patients with pancreatic cancer remain dismal [1]. The overall 5-year relative survival rate for patients reported to the Surveillance, Epidemiology, and End Results (SEER) database of the National Cancer Institute from 1996 to 2004 was 5.1% [2]. Treatment strategies for early respectable and metastatic disease are relatively clear and definite, namely resection plus sequential adjuvant chemotherapy for the former and systemic chemotherapy or supportive care for the latter [3]. The role of radiation therapy in pancreatic cancer continues to be investigated. Randomized trials have yielded conflicting data in locally advanced disease. Also, as radiation techniques have improved over time, findings

in older trials may not be applicable in modern practice [4]. Treatment for pancreatic cancer has been the subject of debate [5]. Despite, and often because of, the results of multiple contradictory clinical trials that have examined various management strategies, the optimal manner in which pancreatic cancer should be treated ultimately rests in the judgment and preferences of the individual oncologist [6]. At the center of much of this controversy is radiation therapy. Therefore, to further investigate the relationship between adjuvant radiation therapy and pancreatic cancer patient prognosis, we used data from the Surveillance, Epidemiology, and End Result (SEER) database to explore the impact of adjuvant radiation on cancer-specific survival in pancreatic cancer patients who received surgical resection.

METHODS

Study Population

A retrospective cohort was identified using the Surveillance, Epidemiology and End Results (SEER) database, a project sponsored by the National Cancer Institute [7,8]. The SEER database was established in 1973 and is a set of extensive population-based cancer registries that cover approximately 28% of the US population (Alaska Native Tumor Registry, Connecticut, Georgia Center for Cancer Statistics, San Francisco-Oakland, San Jose-Monterey, Greater California, Hawaii, Idaho, Iowa,

Received February 23rd, 2021 - Accepted March 05th, 2021

Keywords Pancreatic neoplasms; Pancreas cancer; Radiosurgery; Stereotactic; Stereotactic body radiation therapy (SBRT); Radiation; Radiotherapy

Correspondence: Muhammad Wasif Saif

Northwell Health Cancer Institute
Donald and Barbara Zucker School of Medicine at Hofstra,
Feinstein Institute for Medical Research
Lake Success, NY, USA
Tel: 5163212238
E-mail: wsai@northwell.edu

Kentucky, Los Angeles, Louisiana, Massachusetts, New Mexico, New York, Seattle- Puget Sound, Utah). We queried the November 2018 submission from 1973 to 2015. Using the International Classification of Disease, Third Edition (ICD-O-3) codes, we queried for Primary site "Pancreas". Inclusion criteria were set as adenocarcinomas of the exocrine pancreas. Since data in the SEER database is de-identified, our study is exempt from Institutional Review Board review.

Selection of variables

Variables of interest included the year of diagnosis, patient demographics (age at diagnosis, gender, race, and marital status), tumor characteristics (stage, grade, and tumor size), surgery technique and details, radiotherapy or chemotherapy administered, as well as survival in months and patient status at the end of follow up period. The race was recorded as white, black, Spanish-Hispanic-Latino, Asian, and others.

Survival was defined as months from the time of diagnosis to the point of last contact or the date of death in cases where the patient was deceased. Patient status at the end of the follow-up period was recorded as alive or deceased.

Statistical analysis

Data extracted from the SEER database was imported on to the statistical package for the social sciences (SPSS) version 23 IBM Corp, USA for analysis [8]. Both descriptive and inferential analysis was conducted. Characteristics of our sample population were described using frequencies, percentages, means, and medians. Survival was estimated using the Kaplan–Meier curve. Survival differences between variables were compared using the log-rank test. We subsequently computed propensity scores to assess the probability of being assigned to a treatment group (surgery only or surgery plus adjuvant radiation) based on the observed patient's demographic, and pretreatment clinical characteristics. The logistic regression model was used to calculate the propensity scores derived from these confounding preoperative parameters. These variables included age, sex, race, year of diagnosis, marital status, and preoperative tumor characteristics (size, grade, tumor location). The most appropriately matched pairs were selected based on the propensity scores using a 1:1 nearest neighbor algorithm (R-plugin 2.14.2 for SPSS vs. 21.0). A p-value of less than 0.05 was considered significant. Confidence intervals (CI) were set at 95%. Multivariate Cox-regression was used to study the relationship between various patient and disease-specific factors and survival.

RESULTS

A total of 10,224 patients met our inclusion criteria with 6768 (66.2%) patients treated with surgery only and 3456 (33.8%) treated with surgery plus adjuvant radiation. **Table 1** compares the baseline characteristics of the two groups. Significant differences between patient demographics and tumor characteristics were demonstrated.

Unmatched survival analysis

Patients who underwent surgery plus adjuvant radiation had a significantly higher overall survival (OS) than patients who underwent surgery only ($p < 0.001$). The median OS values were 21 and 16 months for surgery plus adjuvant radiation and surgery only respectively.

Propensity Score Matching and Multi-variate Survival Analysis

Propensity matching yielded 5766 patients (2883 matched pairs) from surgery plus adjuvant radiation and surgery only groups. There were no significant differences in baseline characteristics between the two groups after matching (**Table 2**).

Patients following surgery plus adjuvant radiation had significantly higher OS when compared to patients undergoing surgery only ($p < 0.001$). The median OS values were 21 and 16 months for surgery plus adjuvant radiation and surgery only respectively.

We further investigated the correlation between OS and other covariates in a Cox Regression Analysis. Multivariate analysis demonstrated that surgery plus adjuvant radiation was associated with significantly improved survival (HR: 0.753, CI: 0.718 – 0.789, $p < 0.001$). Additionally, female gender and married status were associated with better survival ($p < 0.05$) while advanced age, Caucasian race, higher TNM stage, and higher grade had worse survival outcomes ($p < 0.05$) (**Table 3**).

Predictors of adjuvant radiation

In a logistic regression model evaluating factors associated with receipt of adjuvant radiation (**Table 4**), older age, prior or current marital status, and higher T and N stages were associated with receipt of adjuvant radiation. Spanish-Hispanic-Latino and Asian races and higher M stages were associated with adjuvant radiation not being administered.

Table 1: Unmatched Univariate Analysis of Factors Associated with therapy (n = 10232).

Variable	Surgery only (n = 6768)	Surgery plus adjuvant radiation (n = 3456)	p value
Mean age at time of diagnosis (±SD)	66.78 (± 10.68)	63.34 (9.88)	< 0.001
Male gender	3380 (49.9%)	1842 (53.3%)	0.001
Race			
White	4808 (71.0%)	2530 (73.2%)	< 0.001
Black	651 (9.6%)	369 (10.7%)	
Spanish-Hispanic-Latino	712 (10.5%)	299 (8.7%)	

Asian	488 (7.2%)	191 (5.5%)	
Other	109 (1.6%)	67 (1.9%)	
Marital Status			
Single	849 (12.5%)	383 (11.1%)	< 0.001
Married	4239 (62.6%)	2352 (68.1%)	
Divorced/ Separated	742 (11.0%)	399 (11.5%)	
Widowed	938 (13.9%)	322 (9.3%)	
Tumor location			
Head	5230 (77.3%)	2760 (79.9%)	0.01
Body	445 (6.6%)	220 (6.4%)	
Tail	714 (10.5%)	290 (8.4%)	
Duct	80 (1.2%)	38 (1.1%)	
Overlapping lesion	299 (4.4%)	148 (4.3%)	
Tumor T stage			
T1	412 (6.1%)	126 (3.6%)	< 0.001
T2	815 (12.0%)	403 (11.7%)	
T3	5237 (77.4%)	2755 (79.7%)	
T4	304 (4.5%)	172 (5.0%)	
Tumor N stage			
N0	2291 (33.9%)	969 (28.0%)	< 0.001
N1	4477 (66.1%)	2487 (72.0%)	
Tumor M stage			
M0	6245 (92.3%)	3398 (98.3%)	< 0.001
M1	523 (7.7%)	58 (1.7%)	
Tumor Grade			
Low grade, Grade I	727 (10.7%)	325 (9.4%)	0.006
Intermediate grade, Grade II	3400 (50.2%)	1844 (53.4%)	
High grade, Grade III	2641 (39.0%)	1287 (37.2%)	
Mean tumor size in cm (±SD)	3.55 (±2.11)	3.52 (±1.72)	0.001

Table 2: Matched Univariate Analysis of Factors Associated with therapy (n = 5766).

Variable	Surgery only (n = 2883)	Surgery plus adjuvant radiation (n = 2883)	p value
Mean age at time of diagnosis (±SD)	64.73 (± 10.05)	64.63 (9.31)	0.695
Male gender	1490 (51.7%)	1502 (52.1%)	0.752
Race			
White	2068 (71.7%)	2104 (73.0%)	0.76
Black	310 (10.8%)	282 (9.8%)	
Spanish-Hispanic-Latino	269 (9.3%)	271 (9.4%)	
Asian	184 (6.4%)	177 (6.1%)	
Other	52 (1.8%)	49 (1.7%)	
Marital Status			
Single	344 (11.9%)	344 (11.9%)	0.823
Married	1891 (65.6%)	1903 (66.0%)	
Divorced/ Separated	354 (12.3%)	332 (11.5%)	
Widowed	294 (10.2%)	304 (10.5%)	
Tumor location			
Head	2288 (79.4%)	2300 (79.8%)	0.754
Body	168 (5.8%)	176 (6.1%)	
Tail	255 (8.8%)	258 (8.9%)	
Duct	37 (1.3%)	33 (1.1%)	
Overlapping lesion	135 (4.7%)	116 (4.0%)	
Tumor T stage			
T1	106 (3.7%)	119 (4.1%)	0.78
T2	335 (11.6%)	341 (11.8%)	
T3	2324 (80.6%)	2299 (79.7%)	
T4	118 (4.1%)	124 (4.3%)	
Tumor N stage			
N0	864 (30.0%)	874 (30.3%)	0.774
N1	2019 (70.0%)	2009 (69.7%)	
Tumor M stage			
M0	2824 (98.0%)	2825 (98.0%)	0.926

M1	59 (2.0%)	58 (2.0%)	
Tumor Grade			
Low grade, Grade I	277 (9.6%)	278 (9.6%)	0.741
Intermediate grade, Grade II	1479 (51.3%)	1506 (52.2%)	
High grade, Grade III	1127 (39.1%)	1099 (38.1%)	
Mean tumor size in cm ($\pm$ SD)	3.50 ($\pm$ 1.75)	3.52 ($\pm$ 1.74)	0.637

Table 3: Predictors of Adjuvant Radiation on Logistic Regression.

Variable	OR (95% CI)	p value
Mean age at time of diagnosis	0.967 (0.963 – 0.971)	P < 0.001
Female gender	0.973 (0.891 – 1.062)	0.54
Race		
White	1	
Black	1.013 (0.878 – 1.169)	0.856
Spanish-Hispanic-Latino	0.745 (0.642 – 0.864)	P < 0.001
Asian	0.716 (0.599 – 0.875)	P < 0.001
Other	1.201 (0.873 – 1.652)	0.261
Marital Status		
Single	1	
Married	1.457 (1.270 – 1.671)	P < 0.001
Divorced/ Separated	1.270 (1.065 – 1.514)	0.008
Widowed	1.177 (0.973 – 1.423)	0.093
Tumor location		
Head	1	
Body	1.063 (0.892 – 1.266)	0.496
Tail	0.919 (0.791 – 1.069)	0.274
Duct	1.025 (0.686 – 1.532)	0.903
Overlapping lesion	0.998 (0.809 – 1.232)	0.984
Tumor T stage		
T1	1	
T2	1.660 (1.308 – 2.108)	P < 0.001
T3	1.725 (1.394 – 2.136)	P < 0.001
T4	2.163 (1.624 – 2.880)	P < 0.001
Tumor N stage		
N0	1	
N1	1.226 (1.114 – 1.348)	P < 0.001
Tumor M stage		
M0	1	
M1	0.175 (0.132 – 0.231)	P < 0.001
Tumor Grade		
Low grade, Grade I	1	
Intermediate grade, Grade II	1.153 (0.995 – 1.337)	0.058
High grade, Grade III	1.022 (0.877 – 1.190)	0.78

Table 4: Cox Survival Analysis.

Variable	HR (95% CI)	p value
Mean age at time of diagnosis	1.014 (1.012 – 1.016)	P < 0.001
Female gender	0.910 (0.870 – 0.952)	P < 0.001
Race		
White	1	
Black	1.117 (1.037 – 1.204)	0.004
Spanish-Hispanic-Latino	1.101 (1.022 – 1.186)	0.012
Asian	1.021 (0.933 – 1.177)	0.655
Other	0.917 (0.773 – 1.089)	0.323
Marital Status		
Single	1	
Married	0.907 (0.846 – 0.973)	0.007
Divorced/ Separated	1.032 (0.943 – 1.130)	0.495
Widowed	1.042 (0.950 – 1.144)	0.382
Tumor location		
Head	1	

Body	1.000 (0.912 – 1.096)	0.992
Tail	1.007 (0.934 – 1.086)	0.858
Duct	1.104 (0.905 – 1.347)	0.33
Overlapping lesion	1.077 (0.968 – 1.197)	0.172
Tumor T stage		
T1	1	
T2	1.534 (1.347 - 1.746)	P < 0.001
T3	1.759 (1.563 – 1.978)	P < 0.001
T4	2.658 (2.288 – 3.088)	P < 0.001
Tumor N stage		
N0	1	
N1	1.433 (1.363 – 1.507)	P < 0.001
Tumor M stage		
M0	1	
M1	1.896 (1.732 – 2.075)	P < 0.001
Tumor Grade		
Low grade, Grade I	1	
Intermediate grade, Grade II	1.359 (1.254 – 1.473)	P < 0.001
High grade, Grade III	1.732 (1.595 – 1.880)	P < 0.001
Adjuvant Radiation	0.753 (0.718 – 0.789)	P < 0.001

DISCUSSION

Our study showed a survival benefit in patients who received adjuvant radiation therapy for pancreatic cancer. This study adds to the growing literature of retrospective studies on the role of radiation therapy following pancreatic resection and highlights the need for a large multicenter randomized trial.

Radiation therapy represents a highly complex and technical treatment that is rapidly evolving. The modality has undergone and continues to undergo, dramatic transformations with advances in computational modeling and medical imaging [9,10]. These advances will only continue to accelerate in the coming years and will likely follow a "double exponential" growth pattern leveraging advances in both hardware and software capabilities. While radiation therapy has historically been described as a singular entity in oncologic management it represents a broad treatment class, inclusive of a wide range of treatment procedures and methods. Despite the spectrum of potential treatments under the category of radiation therapy, the all-encompassing nomenclature may obscure the heterogeneity that exists within the term radiation therapy.11

The GITSG trial randomized patients with pancreatic adenocarcinoma resected to negative margins to 40 Gy delivered with 2 Gy daily fractions with a split course (2-week break after the first 20 Gy were delivered) with concurrent 5-FU chemotherapy versus observation alone [11]. Five-year OS was 15% vs. 5% and median disease-free survival (DFS) was 11 vs. 9 months, both favoring the adjuvant chemoradiotherapy arm. The trial was closed early due to poor accrual. However, this trial helped establish adjuvant chemoradiotherapy (CRT) as the standard of care in the United States.

Our results are in concordance with prior studies of adjuvant radiation therapy for pancreatic cancer. Cox analysis conducted by Blain et al. found that receiving EBRT was an independent prognostic factor for an improved

hazard ratio of dying from pancreatic cancer (HR=0.65, $p<0.0001$) [12]. Sugawara and Kunieda analyzed 2,532 patients from the SEER database treated with surgery plus/minus adjuvant radiotherapy from 2004 to 2009 [13]. They also found a survival advantage in the radiotherapy group. Overall survival (OS) was 20 months vs. 16 months in the adjuvant radiotherapy and observation groups, respectively ($p<0.0001$). Disease-specific survival was 22 months vs. 18 months in the adjuvant radiotherapy and observation arms, respectively. Opfermann et al. analyzed 3,314 patients from the SEER database treated with surgery plus/minus adjuvant radiotherapy from 1998 to 2006 [14]. They also found a survival advantage in the radiotherapy group. OS was 19 months vs. 14 months favoring the radiotherapy arm ($p<0.001$). The expanded timeframe of our study is promising for the continued use of this adjuvant therapy. Moreover, we found that the type of surgery performed, and the location of the tumor does not influence the benefit of adjuvant radiation. Alternatively, the relatively short lifespan of these patients could mean that survival differences are potentially attributable to the type of surgery performed and the location of the tumor, both of which do not appear within the available follow-up period.

Concerning trends regarding potential disparities in the utilization of radiation therapy emerged from our analysis. Namely, those white patients were more likely to receive adjuvant radiation than Asian and Spanish-Hispanic-Latino patients. Shavers et al similarly found that Hispanic patients were less likely to receive radiation therapy for pancreatic cancer than non-Hispanic whites (OR 0.50, 95% CI, 0.27–0.95) [15]. Gad et al found an increasing trend of pancreatic adenocarcinoma incidence-based mortality among Asian-American patients, with an annual increase of 4.535% (95%CI 3.538-5.541; $P<0.001$) from 1992 to 2015 [16]. Their SEER analysis did not include trends in radiation therapy. In concordance with our data, Eloubeidi et al. identified no difference in radiation therapy by race when comparing black and white patients (15.0%

vs. 14.2% for white's vs. blacks, $P=.65$) on analysis of the Alabama Statewide Cancer Registry from 1996 to 2000, however, they did identify that black patients were less likely to receive both chemotherapy (26.78% vs. 32.3%, $P=.02$) and surgery (14.0% vs. 17.0% $P=.09$), which has also been found on SEER analysis [17].

Healthcare inequities in the incidence and mortality of pancreatic cancer are multifaceted. Given the survival advantage identified among patients who receive surgery and adjuvant radiotherapy, ensuring access to such treatment modalities is an important step in improving pancreatic cancer outcomes. Noel and Fiscella identified that black and Hispanic patients with pancreatic cancer had lower rates of surgical resection and were more likely to be treated at low-volume hospitals, proposing that differences in pancreatic cancer outcomes are driven by race and socioeconomic status [18]. Continued analysis of differential utilization of radiation therapy, both on a population and individual patient level, is needed to determine steps towards more equitable treatment.

It is important to note some important disadvantages of using the SEER database. This database does not report chemotherapy data and does not report the dose or duration of radiotherapy. Also, margin status was not available in the SEER database for this group of patients [19-22]. However, previous meta-analyses conducted have suggested that the benefit of adjuvant radiotherapy may be limited to patients with positive margins, so perhaps these patients were more likely to have gotten this adjuvant treatment in the SEER database and thus would be over-represented in the irradiation arm. Therefore, incorporating more information on chemotherapy, radiotherapy, and margin status would be useful in investigating the effects of these factors on survival in pancreatic cancer patients. Data from randomized clinical trials may also aid in the investigation of the impact of various treatment approaches.

References

- Hall WA, Goodman KA. Radiation therapy for pancreatic adenocarcinoma, a treatment option that must be considered in the management of a devastating malignancy. *Radiat Oncol* 2019; 14: 114.
- Ryan DP, Hong TS, Bardeesy N. Pancreatic adenocarcinoma. *N Engl J Med* 2014; 371: 1039-49. [PMID: 25207767].
- Bockhorn M, Uzunoglu FG, Adham M, Imrie C, Milicevic M, Sandberg AA, et al. Borderline resectable pancreatic cancer: A consensus statement by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* 2014; 155: 977-988. [PMID: 24856119].
- Tepper J, Nardi G, Sutt H. Carcinoma of the pancreas: review of MGH experience from 1963 to 1973. Analysis of surgical failure and implications for radiation therapy. *Cancer* 1976; 37: 1519-1524. [PMID: 1260670].
- Gudjonsson B. Cancer of the pancreas. 50 years of surgery. *Cancer* 1987; 60: 2284-2303. [PMID: 3326653].
- Griffin JF, Smalley SR, Jewell W, Paradelo JC, Raymond RD, Hassanein RE, et al. Patterns of failure after curative resection of pancreatic carcinoma. *Cancer* 1990; 66: 56-61. [PMID: 2354408].
- Whittington R, Bryer MP, Haller DG, Solin LJ, Rosato EF. Adjuvant therapy of resected adenocarcinoma of the pancreas. *Int J Radiat Oncol Biol Phys* 1991; 21: 1137-43. [PMID: 1938511].
- Baig MZ, Razi SS, Weber JF, Connery CP, Bhora FY. Lobectomy is superior to segmentectomy for peripheral high grade non-small cell lung cancer ≤ 2 cm. *J Thorac Dis* 2020; 12: 5925-5933. PMID: 33209425.
- Iacobuzio-Donahue CA, Fu B, Yachida S, Luo M, Abe H, Henderson CM, et al. DPC4 gene status of the primary carcinoma correlates with patterns of failure in patients with pancreatic cancer. *J Clin Oncol* 2009; 27: 1806-1813. [PMID: 19273710].
- Kalser MH, Ellenberg SS. Pancreatic cancer. Adjuvant combined radiation and chemotherapy following curative resection. *Arch Surg* 1985; 120: 899-903. [PMID: 4015380].
- No authors listed. Further evidence of effective adjuvant combined radiation and chemotherapy following curative resection of pancreatic cancer. *Gastrointestinal Tumor Study Group Cancer* 1987; 59: 2006-2010. [PMID: 3567862].
- Baine MJ, Lin C. Radiation therapy improves survival outcome in pancreatic adenocarcinoma: comparison of a 15-year institution experience at the University of Nebraska Medical Center with SEER data. *J Radiother* 2014.
- Sugawara A, Kunieda E. Effect of adjuvant radiotherapy on survival in resected pancreatic cancer: A propensity score surveillance, epidemiology, and end results database analysis. *J Surg Oncol* 2014; 110: 960-966. [PMID: 25146251].
- Opfermann KJ, Wahlquist AE, Garrett-Mayer E, Shridhar R, Cannick L, Marshall DT. Adjuvant radiotherapy and lymph node status for pancreatic cancer: Results of a study from the Surveillance, Epidemiology, and End Results (SEER) Registry Data. *Am J Clin Oncol* 2014; 37: 112-116. [PMID: 23211221].
- Shavers VL, Harlan LC, Jackson M, Robinson J. Racial/ethnic patterns of care for pancreatic cancer. *J Palliat Med* 2009; 12: 623-630. [PMID: 19594347].
- Gad MM, Găman MA, Saad AM, Al-Husseini MJ, Shehata OA, Abou Saleh M, et al. Temporal trends of incidence and mortality in Asian-Americans with pancreatic adenocarcinoma: An epidemiological study. *Ann Gastroenterol* 2020; 33: 210-218. [PMID: 32127743].
- Eloubeidi MA, Desmond RA, Wilcox CM, Wilson RJ, Manchikalapati P, Fouad MM, Eltoum I, Vickers SM. Prognostic factors for survival in pancreatic cancer: A population-based study. *Am J Surg* 2006; 192: 322-329. [PMID: 16920426].
- Noel M, Fiscella K. Disparities in pancreatic cancer treatment and outcomes. *Health Equity* 2019; 3: 532-540. [PMID: 31663065].
- Aziz H, Genyk Y, Saif MW, Filkins A, Selby R, Sheikh MR. Review of oncology and transplant literature for the management of hepatic and pancreatic resections in Jehovah's Witnesses. *Cancer Med J* 2021; 4: 16-26. PMID: 32601622. [PMID: 32601622].
- Aziz H, Zeeshan M, Kaur N, Emamaullee J, Ahearn A, Kulkarni S, et al. A potential role for robotic cholecystectomy in patients with advanced liver disease: Analysis of the NSQIP Database. *Am Surg* 2020; 86: 341-345. PMID: 32391758. [PMID: 32391758].
- Aziz H, Hanna K, Saif MW, Rauf MA, Genyk Y, Sheikh MR. Hepatectomy for breast cancer metastasis and sarcoma are more likely to have adverse outcomes than hepatectomy for primary hepatocellular cancer or for colorectal metastasis. *Cancer Med J* 2020; 3: 6-12. PMID: 33196059.
- Aziz H, Zeeshan M, Jie T, Maegawa FB. neoadjuvant chemoradiation therapy is associated with adverse outcomes in patients undergoing pancreaticoduodenectomy for pancreatic cancer. *Am Surg* 2019; 85: 1276-1280. [PMID: 31775971].