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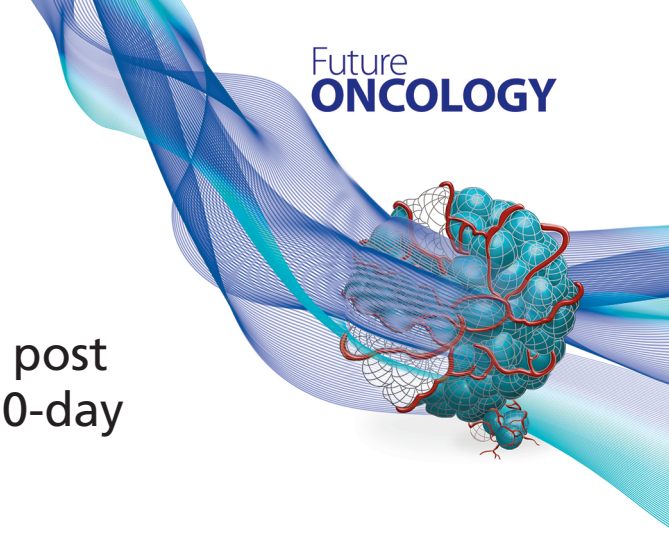

Deviations from a clinical pathway post pancreatoduodenectomy predict 90-day unplanned re-admission

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Aim: To determine the frequency and relevance of deviations from a post pancreatoduodenectomy (PD) clinical care pathway. **Materials & methods:** A retrospective analysis using a prospectively maintained database of a post-PD clinical care pathway was carried out between May 2016 and March 2018. Patients were divided based on the number of factors deviating from the clinical care pathway (Group I: no deviation; Group II: deviation in 1–4 factors; Group III: deviation in 5–8 factors). The analysis included profiling of patients on different demographic and clinical as well as medical and surgical outcome parameters (discharge by postoperative day 8 and 90-day unplanned re-admission rate). **Results:** Post-PD clinical care pathways are feasible but deviations from the pathway are frequent (91%). An increase in frequency of deviations from the pathway was significantly associated with increased risk of POPF and delayed gastric emptying, delayed discharge, risk of mortality and 90-day unplanned re-admission rate. **Conclusion:** Deviations from a post-PD clinical care pathway are common. Poor nutrition and cardiac co-morbidities are associated with an increased likelihood of deviation. As the number of deviations increase, so does the risk of significant complications and interventions, delayed discharge and 90-day re-admission rate.

First draft submitted: 15 February 2020; Accepted for publication: 20 May 2020; Published online: 8 June 2020

Keywords: morbidity • mortality • outcomes • quality • surgery

Re-admission following pancreatic surgery is common and is usually the result of infections or surgical complications [1]. Re-admissions following pancreatoduodenectomy (PD) not only impact on patient mortality, quality of life and survival, they also present an economic burden to the healthcare system [2,3]. It is thus of increasing significance from the patient and healthcare system perspective that we identify predictors of re-admission. This would present an opportunity to intervene at an early stage in the postoperative course of the patient and help institute corrective or remedial measures that would obviate not only the need for re-admission, but more importantly improve patient care.

Clinical pathways are standardized care plans for individual clinical problems that detail essential steps in patient care bearing in mind the expected postoperative course with the overall aim of improving outcomes. They reduce costs by avoiding unnecessary investigations, reducing complications and length of stay [4], and also improve the quality of care through process standardization and decreasing practice variation [5]. We have previously published our successful experience with a post-PD clinical care pathway that helped to reduce the postoperative length of hospital stay without affecting re-admission rates [6]. Acknowledging the impact of infectious complications on patient outcomes post-PD, in general, we further investigated the determinants of surgical site infections as well as the appropriate choice of peri-operative antimicrobials [7,8]. We went on to analyze the need for (or lack of) blood transfusions during PD [9] given its association with poor outcomes and re-admission [1]. We have also teased out

that the main drivers of cost following PD are the length of stay and the development of complications, among other factors [10].

Considering the complexity of PD and the high incidence of morbidity and their attendant risk of mortality, it is important to address the compliance with a clinical care pathway post-PD. There is also a need to understand the relevance of deviations, if any. The aim of the study was to determine the frequency of deviations (lack of compliance) from a post-PD clinical care pathway to determine how deviations influenced postoperative length of stay and the risk of 90-day unplanned re-admissions.

Materials & methods

Patient population

The data of consecutive patients who underwent PD for pancreatic and peri-ampullary lesions (benign and malignant) at the Department of Gastrointestinal Surgery, Gastrointestinal Oncology and Bariatric Surgery, Medanta, The Medicity, Gurgaon, a tertiary referral care center, between May 2016 and March 2018 was obtained from a prospectively maintained database.

Ethics

The study has been approved by the Institutional Review Board and the Ethics Committee of the Medanta, The Medicity (Approval No: MICR-604/2016). An informed consent was obtained from all patients prior to their surgery.

Study design

This is a retrospective analysis using a prospectively maintained database of a post-PD clinical care pathway.

Peri-operative management

The post-PD clinical pathway for postoperative care followed in our Unit has been previously published (Supplementary Table 1) [6]. It was developed along the lines of the ERAS publication of Lassen *et al.* [11] Our peri-operative antibiotic protocol has been previously published [7,8]. The protocol using three, once-daily, peri-operative doses of Ertapenem resulted in a nonsignificant difference in infectious and overall complications between patients deemed high risk (pre-operative endoscopic intervention) as compared with the low risk (up-front surgery) group of patients [7]. Therapeutic use of antimicrobials, including a change in antibiotics, was considered in patients who thereafter developed infectious complications based on the site of infection and appropriate culture and sensitivity report [7,8].

All patients underwent a classical PD, after an overnight fast, via a right subcostal incision with the following reconstruction:

Pancreaticojejunostomy (PJ) – end-to-side, duct-to-mucosa in two layers, hepaticojejunostomy (HJ) – end-to-side, gastrojejunostomy (GJ) – side-side, retrocolic, retrogastric. In patients in whom the pancreatic duct was not visualized, an end-to-side PJ was performed. A standard lymphadenectomy was performed in all patients. The decision on whether or not to place a single drain (32 Fr Portex drain in the Morisson's pouch) intra-operatively was made on a case-by-case basis. Our criteria for placing a drain intra-operatively include patients undergoing surgery who are older than 65 years of age, soft pancreas, inable to visualize the pancreatic duct and perform a 'duct-to-mucosa' pancreatico-enteric anastomosis, multivisceral resection, the need for intra-operative blood transfusion and presence of purulent bile [6].

Patients were considered fit for discharge once they were afebrile, pain-free, tolerated an oral diet (with no requirement for intravenous fluids), ambulatory, with a healthy operative wound and showed willingness for discharge [6].

Deviations in clinical care pathway & study groups

Deviations from the clinical pathway were defined as:

- Inability to remove nasogastric tube on POD 1 (Yes/No);
- Need for reinsertion of nasogastric tube (Yes/No);
- Inability to remove urinary catheter on POD 2 (Yes/No);
- Inability to remove epidural catheter on POD 2 (Yes/No);

- Inability to stop antibiotics on POD 2 (Yes/No);
- Recommencement of antibiotics (Yes/No);
- Inability to remove the intra-abdominally placed surgical drain on POD 3 (Yes/No);
- Commencement of a soft diet on POD 5 (Yes/No).

The patients were divided into three groups based on the number of factors deviating from the clinical care pathway:

- Group I: no deviation;
- Group II: minor deviation (deviation in 1–4 factors or ≤50% factors);
- Group III: major deviation (deviation in 5–8 factors or >50% factors).

The patients in the three groups were compared in terms of their pre-operative co-morbidities, peri-operative outcomes and 90-day re-admission rates.

Definition of complications

For the study, infectious complications were defined as surgical site infections and/or intra-abdominal collections or respiratory infective complications associated with signs of sepsis (transient or prolonged) including fever, elevated leucocytosis and the need for re-initiation of antibiotics.

All other complications including postoperative pancreatic anastomotic leak/fistula (POPF), delayed gastric emptying (DGE), bile leak and post pancreatectomy hemorrhage were defined as per our previous publications as well as by the International Study Group of Pancreatic Surgery (ISGPS) criteria [12–15]. Mortality was defined as any death within 90 days after the operation, regardless of the presumed cause. Any re-admissions within 90 days of discharge, whether in our hospital or another hospital, were recorded.

Statistical analysis

The analysis includes profiling of patients on different demographic and clinical as well as medical and surgical outcome parameters. Descriptive statistics of quantitative variables are expressed as means with standard deviation and median (Range/interquartile range [IQR]). Ordinal/categorical data are expressed in terms of absolute number and percentages. The assessment of normality of data was tested using the Kolmogorov–Smirnov test. Univariate analysis was undertaken with analysis of variance, Kruskal–Willis H-test, and χ^2 test as appropriate for normally distributed continuous, non-normally distributed continuous and categorical variables, respectively. Univariate analysis for prediction of likely discharge on postoperative day 8 and re-admission within 90 days of discharge in the relationship between explanatory variable and length of hospital stay was performed using Cox regression method as well as cox multivariate regression analysis with forward logistic regression (LR) method was performed. $p < 0.05$ is considered statistically significant. All statistical analyses were performed using the IBM Statistical Package for the Social Sciences (SPSS) inc, Version 24.0 for Windows (IBM Corp, NY, USA).

Results

Patient demography

The entire cohort of 162 patients included 112 (69%) men with a median age of 59 (range 19–84) years. The median BMI for the entire cohort was 24.4 kg/m^2 (IQR = 14.4–44.2).

Deviation from the post-PD clinical care pathway

Overall differences in the groups

There were 14 (9%), 84 (52%) and 64 (39%) patients in Groups I, II and III. A detailed comparison between the three groups in terms of demography, co-morbidities and peri-operative variables are presented in Tables 1 & 2. Patients in Group III had a significantly higher BMI ($p < 0.023$), lower serum albumin ($p < 0.008$), and were significantly more likely to have cardiac co-morbidities ($p < 0.03$). They also tended to have longer operating times ($p < 0.046$) and significantly higher risk of complications and need for interventions (including re-admission to the Intensive care Unit), as well as an increased risk of mortality ($p < 0.003$). Only one of the overall ten patients who died, did so, following re-admission. The patient belonged to group 2. A comparison of only the significantly different variables between the three groups are provided in Tables 3 & 4. Table 5 provides detail on the histopathology of the PD specimens as well as the pathological staging for malignant lesions.

Table 1. Comparison between the three groups in terms of demography, co-morbidities, pre- and intra-operative variables.

Parameter	Total (n = 162)	Group I (n = 14)	Group II (n = 84)	Group III (n = 64)	p-value
Demographic factors					
Age (years), median (IQR)	59 (19–84)	58 (29–70)	59 (19–76)	61 (22–84)	0.224
BMI, median (IQR)	24.4 (14.4–44.2)	22.6 (16.2–34.2)	24.3 (14.4–32.7)	25.2 (15.4–44.2)	0.023
American Society of Anesthesiologists grade					
I	63 (38.9)	6 (42.9)	33 (39.3)	24 (37.5)	0.671
II	89 (54.9)	8 (57.1)	47 (56)	34 (53.1)	
III	10 (6.2)	0 (0)	4 (4.8)	6 (9.4)	
Co-morbidities					
Type II Diabetes mellitus	56 (34.6)	2 (14.3)	28 (33.3)	26 (40.6)	0.162
Hypertension	74 (45.7)	7 (50)	32 (38.1)	35 (54.7)	0.126
Cardiac	20 (12.3)	0 (0.0)	12 (14.3)	8 (12.5)	0.030
Pre-operative factors					
Hemoglobin (g/dl), mean ± SD	11.7 ± 1.9	12.4 ± 2	11.8 ± 1.9	11.6 ± 2	0.304
Serum bilirubin total, median (IQR)	1.2 (0.1–15.8)	0.7 (0.3–12.7)	1.2 (0.1–15.8)	1.4 (0.3–15.8)	0.871
Serum bilirubin direct, mean ± SD	2.7 ± 3.8	2.4 ± 3.5	2.8 ± 3.9	2.6 ± 3.7	0.932
Albumin, Mean ± SD	3.7 ± 0.5	3.9 ± 0.4	3.8 ± 0.5	3.6 ± 0.5	0.008
Pre-op biliary drainage	56 (34.6)	3 (21.4)	31 (36.9)	22 (34.4)	0.529
Intra-operative factors					
Pancreas texture:					
– Soft	103 (63.6)	9 (64.3)	54 (64.3)	40 (62.5)	0.725
– Firm	57 (35.2)	5 (35.7)	28 (33.3)	24 (37.5)	
– Hard	2 (1.2)	0 (0)	2 (2.4)	0 (0)	
– MPD Size (mm)	3.0 ± 2.0	3.6 ± 2.0	2.9 ± 2.0	3.0 ± 2.0	0.429
Anastomotic technique:					
– Duct-to-mucosa PJ	118 (72.8)	11 (78.6)	60 (71.4)	47 (73.4)	0.848
– End-to-side PJ	44 (27.2)	3 (21.4)	24 (28.6)	17 (26.6)	
– Feeding jejunostomy	21 (13)	1 (7.1)	8 (9.5)	12 (18.8)	0.202
– Drain	131 (80.9)	13 (92.9)	63 (75.0)	55 (85.9)	0.120
– Intra-Op blood loss (ml), median (IQR)	200 (50–800)	200 (100–500)	200 (50–500)	200 (50–800)	0.097
– Surgery duration (mins), mean ± SD	344.2 ± 73	321.8 ± 77.2	335.1 ± 71.3	361.2 ± 71.8	0.046

Data represented as n (%), unless otherwise stated.
IQR: Interquartile range; MPD: Main pancreatic diameter; PJ: Pancreaticojejunostomy; SD: Standard deviation.

Deviation-specific data

Table 6 provides an overview of the frequency of compliance with, or deviation from the eight components of the clinical care pathway. The most common deviation was inability to stop antibiotics on POD 2 in 121 (75%).

As the number of deviations increased (Group II and III), so did the percentage of patients who developed of complications including DGE (0.0001) and POPF (0.025) as well as their severity by the Clavien-Dindo [16] grade ($p < 0.0001$). This resulted in an attendant need for imaging (CT scans of the abdomen; $p < 0.0001$), total parenteral nutrition ($p < 0.0001$), the placement of a nasojejunal tube for enteral nutrition ($p < 0.003$) and the need for re-admission to the ICU ($p < 0.0001$). Thereby resulting in an increased length of hospital stay ($p < 0.0001$).

Deviations predictive of failure to discharge the patient on postoperative day 8

Patients in group III were significantly more likely to have a hospital stay more than 8 days following PD (Table 4; $p < 0.0001$). The influence of all the clinical care pathway deviations on the likelihood of discharge from hospital on postoperative day 8 based on univariate analysis is depicted in Figure 1. On multivariate analysis, the need to reinsert the nasogastric/Ryle's tube (HR 7.8; 95% CI: 1.8–34.1; $p < 0.007$), inability to commence a soft diet on postoperative day 5 (HR 2.4; 95% CI: 1.3–4.5; $p < 0.005$) and the failure to cease peri-operatively planned

Table 2. Comparison between the three groups in terms of postoperative complications and mortality.

Parameter	Total (n = 162)	Group I (n = 14)	Group II (n = 84)	Group III (n = 64)	p-value
Morbidity					
Clavien-Dindo grade, mean ± SD	1.60 ± 1.43	0.14 ± 0.53	1.02 ± 1.04	2.69 ± 1.27	0.0001
Delayed gastric emptying	70 (43.2)	0 (0.0)	19 (22.6)	51 (79.7)	0.0001
Pancreatic fistula (B/C)	22 (13.7)	0 (0.0)	8 (9.5)	14 (22.2) (11B & 3C)	0.025
Post pancreatectomy hemorrhage	14 (8.6)	0 (0.0)	8 (9.5)	6 (9.4) (1A, 4B & 1C)	0.484
Surgical site infections	59 (36.8)	4 (28.6)	27 (32.1)	28 (44.4)	0.249
Postoperative management					
Need for CT scan	57 (35.6)	2 (14.3)	18 (21.4)	37 (59.7)	0.0001
Parenteral nutritional support (TPN)	54 (33.5)	1 (7.1)	13 (15.5)	40 (63.5)	0.0001
Gastroscopy	13 (8.0)	0 (0.00	4 (4.8)	9 (14.1)	0.061
NJ insertion	10 (6.3)	0 (0.0)	1 (1.2)	9 (14.5)	0.003
Other significant variables					
Length of hospitalization, mean ± SD	10.8 ± 5.8	7.1 ± 1.2	9.4 ± 3.9	14.0 ± 7.3	0.0001
Discharge on day 8	65 (42.2)	13 (92.9)	44 (52.4)	8 (14.5)	0.0001
Hospital re-admission (90 days)	36 (23.7)	1 (7.1)	13 (15.5)	22 (40.7)	0.001
ICU re-admission	20 (12.7)	0 (0)	4 (4.8)	16 (26.2)	0.0001
Mortality	10 (6.2)	0 (0.0)	1 (1.2)	9 (14.1)	0.003

Data represented as n (%), unless otherwise stated.
CT: Computed tomography; ICU: Intensive care unit; NJ: Nasojejunal tube.

Table 3. Demographic, pre- and intra-operative variables noted to be significantly different between the three groups.

Parameter	Total (n = 162)	Group I (n = 14)	Group II (n = 84)	Group III (n = 64)	p-value
Demographic factors					
BMI, median (IQR)	24.4 (14.4–44.2)	22.6 (16.2–34.2)	24.3 (14.4–32.7)	25.2 (15.4–44.2)	0.023
Co-morbidities					
Cardiac, n (%)	20 (12.3)	0 (0.0)	12 (14.3)	8 (12.5)	0.030
Pre-operative factors					
Albumin, mean ± SD	3.7 ± 0.5	3.9 ± 0.4	3.8 ± 0.5	3.6 ± 0.5	0.008
Intraoperative factors					
Surgery duration (mins), mean ± SD	344.2 ± 73	321.8 ± 77.2	335.1 ± 71.3	361.2 ± 71.8	0.046

IQR: Interquartile range; MPD: Main pancreatic diameter; PJ: Pancreaticojejunostomy; SD: Standard deviation.

antibiotics on postoperative day 2 (HR 3.6; 95% CI: 2.0–6.5; $p < 0.0001$) were the three deviations that were significantly associated with a delayed discharge after postoperative day 8.

Deviations predictive of likelihood of re-admission within 90 days of discharge

The overall 30-day and 90-day re-admission rate in the whole cohort were 11 and 23.7%. There were no re-admissions in Group III within 30 days. When the period of follow-up was extended to 90 days, it was noted patients in group III were significantly more likely to be re-admitted within 90 days of discharge following PD (Table 4; $p < 0.001$). The influence of all the clinical care pathway deviations on the likelihood of re-admission within 90 days of discharge from hospital based on univariate analysis is depicted in Figure 2. On multivariate analysis, the need to reinsert the nasogastric/Ryle's tube (HR 3.7; 95% CI: 1.9–7.2; $p < 0.0001$), the inability to commence a soft diet on postoperative day 5 (HR 2.7; 95% CI: 1.6–4.5; $p < 0.0001$), the failure to remove the indwelling urinary catheter on postoperative day 2 (HR 1.9; 95% CI: 1.2–3.0; $p < 0.01$), and failure to cease peri-operatively planned antibiotics on postoperative day 2 (HR 3.1; 95% CI: 1.7–5.4; $p < 0.0001$) were the four deviations that were significantly associated with likelihood of re-admission within 90 days of discharge.

Table 4. Postoperative variables (including morbidity and mortality) noted to be significantly different between the three groups.

Parameter	Total (n = 162)	Group I (n = 14)	Group II (n = 84)	Group III (n = 64)	p-value
Morbidity					
Clavien-Dindo grade, mean ± SD	1.60 ± 1.43	0.14 ± 0.53	1.02 ± 1.04	2.69 ± 1.27	0.0001
Delayed gastric emptying (DGE)	70 (43.2)	0 (0.0)	19 (22.6%)	51 (79.7%)	0.0001
Pancreatic fistula (B/C) (POPF)	22 (13.7)	0 (0.0)	8 (9.5)	14 (22.2) (11B & 3C)	0.025
Postoperative management					
Need for CT scan	57 (35.6)	2 (14.3)	18 (21.4)	37 (59.7)	0.0001
Parenteral nutritional support (TPN)	54 (33.5)	1 (7.1)	13 (15.5)	40 (63.5)	0.0001
NJ insertion	10 (6.3)	0 (0.0)	1 (1.2)	9 (14.5)	0.003
Other significant variables					
Length of hospitalization, mean ± SD	10.8 ± 5.8	7.1 ± 1.2	9.4 ± 3.9	14.0 ± 7.3	0.0001
Discharge on Day 8	65 (42.2)	13 (92.9)	44 (52.4)	8 (14.5)	0.0001
Hospital re-admission (90 days)	36 (23.7)	1 (7.1)	13 (15.5)	22 (40.7)	0.001
ICU re-admission	20 (12.7)	0 (0)	4 (4.8)	16 (26.2)	0.0001
Mortality	10 (6.2)	0 (0.0)	1 (1.2)	9 (14.1)	0.003

CT: Computed tomography; ICU: Intensive care unit; NJ: Nasojejunal tube.

Table 5. Histopathological data of the pancreatoduodenectomy specimens and pathological staging for malignant lesions of the pancreatic head and peri-ampullary region subclassified by patient group.

Histopathology & tumor location	Patients (n)	Group stratification		
		Group I (n = 14)	Group II (n = 84)	Group III (n = 64)
Malignancy				
Adenocarcinoma:				
– Peri-ampullary	104	6	53	45
– Head of pancreas	30	6	13	11
– Stomach	1	0	0	1
Lymphoma (DLBCL):				
– Stomach (invading HOP)	1	0	0	1
– Cystic neoplasms	6 (5 IPMN + 1 MCN)	0	3	3
– Neuroendocrine tumors	5	0	4	1
– Solid pseudopapillary tumors	4	1	3	0
Benign				
Chronic pancreatitis	9	1	7	1
Others:				
– Enteritis cystica profunda	1	0	1	0
– Brunner gland hyperplasia	1	0	0	1
Primary tumor (T)				
T1		0	6	5
T2		5	25	19
T3		6	26	25
T4		1	9	7
Nodal status (N)				
N0		5	34	29
N1		7	30	26
N2		0	2	1

DLBCL: Diffuse large B-cell lymphoma; HOP: Head of pancreas; IPMN: Intraductal papillary mucinous neoplasm; MCN: Mucinous cystic neoplasm.

Table 6. Frequency of compliance with/deviation from the eight components of the clinical care pathway.

Deviations	Number (n = 162)	Percent (%)
NG tube removed on POD 1	134	82.7%
Re-insertion of NG tube	48	30.2%
Soft diet on POD 5	66	40.7%
Removal of surgical drain on POD 3	34	26.6%
Removal of IDC POD 2	69	42.6%
Removal of epidural catheter on POD 2	82	50.6%
Cessation of antibiotics on POD 2	41	25.3%
Recommencement of antibiotics	19	12.4%

IDC: In-dwelling urinary catheter; NG: Nasogastric; POD: Postoperative day.

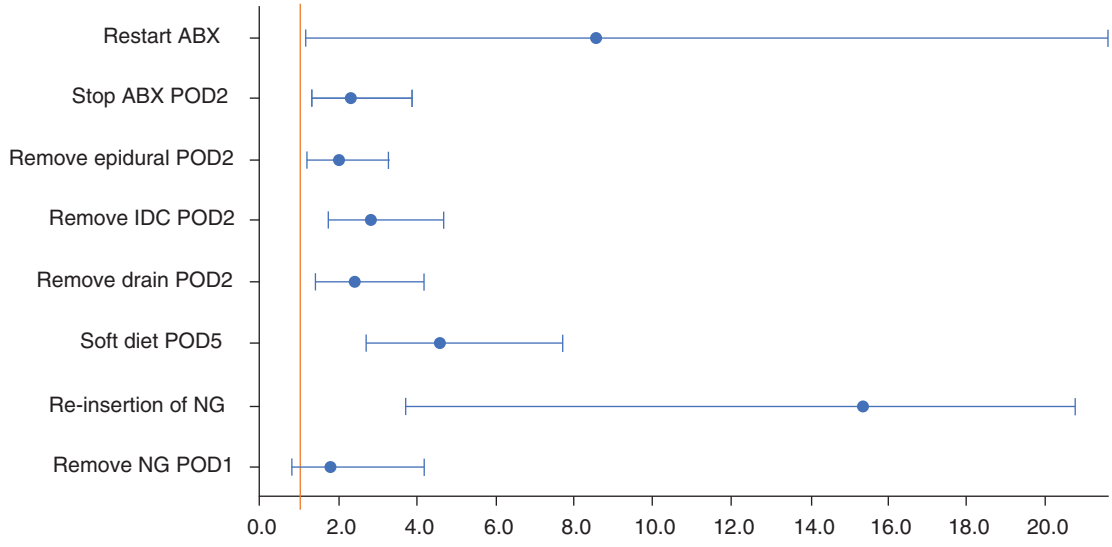

Figure 1. Influence of individual deviations (expressed as hazard ratios) from the clinical care pathway on the likelihood of successful discharge on postoperative day 8.
ABX: Antibiotic; IDC: In-dwelling urinary catheter; NG: Nasogastric tube.

Discussion

These data confirm that post-PD clinical care pathways are feasible but deviations from the pathway are frequent (91%). However, these deviations do not interfere with the intent of the pathway, which is to enhance the postoperative recovery of the patient as evidenced by an acceptable median length of hospital stay. Patients with a higher BMI, low serum albumin and cardiac co-morbidities are among the cohorts more likely to be associated with deviations. An increase in frequency of deviations from the pathway was significantly associated with increased risk of POPF and DGE, a delayed discharge, risk of mortality and re-admission within 90 days. Most parameters (failure to cease antibiotics, removal of the indwelling urinary catheter or commencement of a soft diet on postoperative day 5) that were found to be significant, clearly suggest that most deviations from care pathways are decided by doctors based on clinical judgement [17] and hence cannot be strictly regarded as issues of non-compliance. The significantly poorer outcomes (delayed discharge and need for re-admission) of these patients (who deviated), is a testament to the importance of clinical acumen and decision making in the care of the patient and not a mere reliance on the rigidity of protocols.

We have previously demonstrated the effectiveness of a clinical care pathway resulting in shortened post-PD hospital stays when compared with data from centers around the world [6]. In that study, we had observed that a higher BMI was associated with a longer hospital stay. The present study demonstrates the influence of a higher

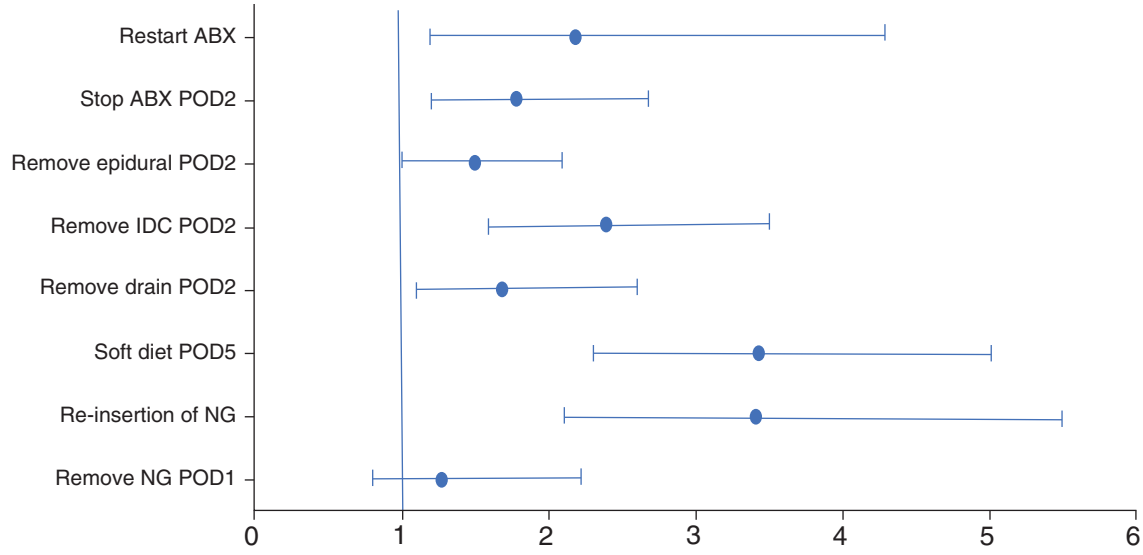

Figure 2. Influence of individual deviations (expressed as hazard ratios) from the clinical care pathway on the likelihood of re-admission within 90 days.
ABX: Antibiotic; IDC: In-dwelling urinary catheter; NG: Nasogastric tube.

BMI on the frequency of deviations in the clinical care pathway. While the overall BMI often tends to be lower in Asian patients, this necessarily does not reflect healthier leaner patients. The reasons for this are twofold. First, the metabolic injury incurred by Asians is significantly higher at a lower BMI [18]. Second, the low albumin noted in this, and previous studies from the subcontinent [19] indicate the poor nutritional status of patients – a marker of poor outcomes in pancreatic surgery [20,21]. Thus, obesity and cachexia, beyond either ends of the spectrum of what is regarded as normal BMI, represent states of malnutrition with proven poor outcomes. The impact of cardiac co-morbidities on early outcomes, including a significantly increased risk of mortality, following pancreatic resectional surgery has been reported from an analysis of data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) [22]. Our study corroborates these findings proposing a likely influence of cardiac co-morbidities on an increased risk of deviation from a clinical care pathway post-PD.

Complications following PD remain a major area of focus as they lead to prolong hospitalization, increase the risk of mortality and represent an economic burden [6,10,12–14,23,24]. The impact of main pancreatic duct diameter and gland texture on the incidence of surgical complications is well appreciated prompting a suggestion for a tailored approach [25,26]. We have traditionally tailored the technique of PJ taking into account these factors using a two-layer interrupted duct-to-mucosa anastomosis in the setting of a favorable anatomy and a single layer end-to-side anastomosis for unfavorable anatomy [6,8]. In this study, we have been unable to demonstrate a significant difference in frequency of deviation based on duct size and gland texture. We can only conjecture that the 'tailored' approach seems to serve us well. The ability to predict the development of complications post-PD early in the postoperative course remains challenging [27] as intra-operatively placed drains do not help [28] and radiology may be misleading [29]. The findings in the study that deviations that can be detected as early as the second postoperative day and may serve as an objective guide to alert clinicians to the likelihood of development of complications. The 90-day mortality rate in our study was 6.2%. This appears high when compared with contemporary literature that indicates that post-PD mortality must be less than 5% [30,31] in high-volume centers. However, we have presented 90, and not, 30-day mortality that is routinely reported in literature. Swanson *et al.* [32] analyzed the outcomes from more than 20,000 pancreatic resections and concluded that 90-day mortality is twice the 30-day mortality (7.4 vs 3.7%).

We studied the influence of deviations from the clinical care pathway using a length of stay of 8 days as the cutoff based on our initial experience with the pathway [6] as well as the experience of other surgeons who have used clinical pathways post-PD [33–36]. We have successfully used a 3-day once daily peri-operative antibiotic regimen

(Ertapenem) as part of our peri-operative clinical pathway [7,8] unlike other surgeons who may use antibiotics for a longer period [37]. The findings in our study seem to support our practice and we can infer that need to continue the antibiotics beyond the second postoperative day is an indicator of an evolving complication. The need to re-insert the nasogastric tube reflects delayed bowel function – representing DGE as a result of aberrant motility [38] or physiological reflexes [39], or an ileus resulting from sinister complications such as an evolving POPF. All of these could also contribute to the inability to initiate a normal diet by postoperative day 5 leading to a delayed discharge.

The applicability of the results of our study to other institutes that do not use the same, or similar, pathway, lies in the appreciation that our study lends support to the concept that development process of quality improvement programs lead to changes in practice [40] for the betterment of patient care. In our experience, since the adoption of the clinical care pathway, we have been able to consistently maintain a short postoperative length of stay [6]. In terms of the application of the results of our study to other healthcare systems, one must appreciate that the intricacies of cross-system comparisons should be undertaken and interpreted with much caution, because length of hospital stay depends on a wealth of factors including habits, psychosocial determinants and posthospital care options. This study also presents another important benefit of a clinical care pathway – the ability to predict 90-day re-admissions. The 90-day unplanned re-admission rate in our study of 23.7% appears higher than reports in literature (4–15%) [34,41]. Once again, we wish to draw the reader's attention to the fact that in literature, it is standard practice to report 30-day re-admissions. Our rate compares well with other high-volume centers (<29%) [42]. A recent publication by Altieri and colleagues [43] has suggested that from a quality of care perspective, 30-day re-admission rates are inadequate. Our findings clearly indicate that the same deviations from a clinical care pathway that predicted delayed discharge, by their inherent ability to predict the development of serious complications as early as within the first five postoperative days, have the potential to predict 90-day re-admissions. This information is novel and empowering to surgeons in terms of planning the care of the patient at discharge. The availability of this information helps flag those patients who need to be followed up more frequently following discharge. This will allow an early detection of problems giving the surgeons a lead-time rather than having to play 'catch-up' once the complication has evolved to a stage that it threatens the life of the patient. The findings of the study present us with the opportunity to direct our attention to the specific cohort of patients (need for reinsertion of nasogastric, inability to initiate a soft diet on postoperative day 5 and inability to cease peri-operative antibiotics on day 2) to determine whether providing focused/planned interventions could help 'alter their course' to achieve a more favorable outcome. The next step would be to revisit our clinical pathway in order to revise it to improve the outcomes of our patients, especially targeting the patients in Group 3.

The strengths of this paper are the prospective nature of data maintenance, the use of an established clinical pathway, and a reasonable cohort size sufficiently large enough to draw conclusions.

Conclusion

Deviations from a post-PD clinical care pathway are common. However, these deviations do not interfere with the intent of the pathway – which is to enhance the postoperative recovery of the patient as evidenced by an acceptable median length of hospital stay. Poor nutrition (high BMI and low albumin) and cardiac co-morbidities are associated with an increased likelihood of deviation. As the number of deviations increase, so does the risk of significant complications and interventions, delayed discharge and 90-day re-admission rate.

Author contributions

M Karunakaran: Data collection and analysis, drafting of manuscript. SG Barreto: Conceptualization and study design; data analysis and drafting the manuscript. MK Singh: Data analysis and critical review of the manuscript. D Kapoor: Data collection and critical review of the manuscript. A Chaudhary: Conceptualization of the study; critical review of the manuscript. All five authors: Final approval of the version to be published; AND Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

Ethical conduct of research

The study has been approved by the Institutional Review Board and the Ethics Committee of the Medanta, The Medicity (Approval No: MICR-604/2016). An informed consent was obtained from all patients prior to their surgery.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Summary points

- Post pancreatoduodenectomy clinical care pathways are feasible.
- These pathways facilitate patient recovery and reduce postoperative hospital stay.
- Deviations to the pathway are common.
- Malnutrition and cardiac co-morbidities increase the likelihood of deviation.
- Minor deviations do not appear to alter the benefit or intent of the pathway.
- As the number of deviations increase, so does the risk of significant complications and interventions, delayed discharge and 90-day re-admission rate.
- Future studies are warranted to develop planned initiatives to target patients with major deviations.

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