

## Whipple's operation with a modified centralization concept: A model in low-volume Caribbean centers

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### Abstract

Conventional data suggest that complex operations, such as a pancreaticoduodenectomy (PD), should be limited to high volume centers. However, this is not practical in small, resource-poor countries in the Caribbean. In these settings, patients have no option but to have their PDs performed locally at low volumes, occasionally by general surgeons. In this paper, we review the evolution of the concept of the high-volume center and discuss the feasibility of applying this concept to low and middle-income nations. Specifically, we discuss a modification of this concept that may be considered when incorporating PD into low-volume and resource-poor countries, such as those in the Caribbean. This paper has two parts. First, we performed a literature review evaluating studies published on outcomes after PD in high volume centers. The data in the Caribbean is then examined and we discuss the incorporation of this operation into resource-poor hospitals with modifications of the centralization concept. In the authors' opinions, most patients who require PD in the Caribbean do not have realistic opportunities to have surgery in high-volume centers in developed countries. In these settings, their only options are to have their operations in the resource-poor, low-volume settings in the Caribbean. However, post-operative outcomes may be improved, despite low-volumes, if a modified centralization concept is encouraged.

**Key Words:** Pancreas; Surgery; Pancreatectomy; Whipple's; Pancreaticoduodenectomy

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**Core Tip:** The published data generally support pancreaticoduodenectomies (PD) being reserved for high volume hospitals. However, this is not practical in resource-poor, low volume countries in the Caribbean. Nevertheless, we have documented good short-term outcomes after PD in this setting. In this paper we discuss a modified centralization concept used to incorporate PD into these low volume centers.

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## INTRODUCTION

Pancreaticoduodenectomy (PD) is a technically complex operation that is accompanied by high complication rates. Although post-operative morbidity has declined over the past 2-3 decades with better supportive care, 30%-50% of patients still experience post-operative complications[1]. Due to PD's high-morbidity profile, specialized hospitals began to appear at the turn of the 21<sup>st</sup> century where hepatopancreatobiliary (HPB) services were concentrated. This drove the "high-volume center" concept in developed countries with large populations, and it was fueled by good outcome data emerging from these centers. A change in referral patterns followed, where patients with peri-ampullary lesions were sent to these experienced centers for multidisciplinary teams to perform PDs at high volumes. This was the birth of the era of service centralization and terminology evolved from "experienced centers"[2] to "high-volume centers"[3].

In this paper, we discuss our experience incorporating PD into this low-volume, resource-poor region.

## DATA FROM HIGH-VOLUME CENTRES

At the turn of the 21<sup>st</sup> century, published data emerged to show that high volume centers performed PDs with significantly reduced overall morbidity[1-8], thirty-day mortality[1,8] readmission rates[3], cost[3,9], duration of hospital stay[3,9] and 5-year survival rates[1,8,10]. These data supported the principle of centralization - a concept that seemed predictable and intuitive on first glance.

However, a closer look at the existing data revealed that there was no standardized definition of "high volumes", with researchers applying ad-hoc definitions that ranged from as low as 2 PDs annually[6,8] to as high as 125 PDs annually[11]. We conducted a systematic literature search across the PubMed, Medline and Google Scholar platforms seeking publications that defined "high-volume" hospitals, using the search terms: "high-volume", "experienced", "centers of excellence", "referral centers" and "specialty centers". The literature search was performed by two researchers and spanned the 27-year period from January 1, 1995 to December 31, 2021. All studies identified were retrieved and reviewed in detail by both researchers who extracted the following data: definition of high-volume center, mortality in low and high-volume centers and study population. We excluded studies that did not document these data, studies with missing data and duplicated studies. The results are outlined in Table 1[1-30]. Most studies demonstrated significant differences in 30-d mortality, but the definitions of "high volume" varied widely. Most papers in the literature quoted numbers  $\geq 20$  PDs per annum[1,3,4,9,16,17,25].

## ARGUMENTS AGAINST REGIONALIZATION

Although data accumulated to support service centralization in developed countries, the concept faced several challenges.

### **Unclear definitions of "high volume"**

With the presumption that medical literature will soon adopt a standardized definition of "high volume" equating to  $\geq 20$  PDs per annum (Table 1), there are few hospitals across the globe that would qualify as high-volume centers. This creates a logistic problem because it would be impractical for patients to be routed to few centers across the globe for PD. This is especially unrealistic in the

**Table 1 Summary of studies comparing peri-operative mortality according to hospital volumes**

Author	Peri-operative mortality		P	Study population	Definition of high volume (cases per annum)
	Low volume	High volume			
Lieberman <i>et al</i> [2], 1995	18.9%	5.5%	< 0.001	2233 PDs over 8 years in New York, USA from 1984-1991	Minimal: < 10; Low: 10-50; High: > 50
Glasgow <i>et al</i> [9], 1996	14.1%	3.5%	0.0009	1424 PDs using data from the California Office of Health wide State Planning and Development from 1990-1994	I (Low): 1-5'; II: 6-10; III: 11-20; IV: 21-30; V: 31-50; VI (High): 50
Sosa <i>et al</i> [3], 1998	18.8%	0.9%	< 0.001	449 PDs + 47 total pancreatectomies from 48 non-federal hospitals in Maryland, USA from 1990-1995	Low: < 5; Medium: 5-19; High: > 20
Birkmeyer <i>et al</i> [5], 1999	16%	4%	< 0.0001	7229 PDs from the US-based Medicare database from 1992-1995	Very Low: < 1; Low: 1-2; Medium: 2-5; High: > 5
Gouma <i>et al</i> [12], 2000	13.2% (Cutoff III)	8.1% (Cutoff III)	NS	1126 patients from 1994-1998 from the National Medical Registry in the Netherlands	I: < 5; II: 5-10; III: 10-25; IV: > 25
Kotwall <i>et al</i> [6], 2002	12.6%	9%	< 0.001	24926 PDs from the US-based National Inpatient Database from 1988-1995	Low: ≤ 1; High: > 1
Nordback <i>et al</i> [13], 2002	13%	4%	< 0.005	350 PDs from the National Hospital Discharge Database in Finland from 1990-1994	Low: < 5; Medium: 5-10; High: > 10
Finlayson <i>et al</i> [14], 2003	11%	3%	< 0.001	3414 pancreatic resections (unspecified) from the US based Nationwide Medicare Database from 1994-1999	Very Low: < 1; Low: 1-2; Medium: 3-4; High: 5-13; Very High: > 13
Ho <i>et al</i> [7], 2003	14.6%	4.7%	< 0.0001	6709 PDs in California and Florida (from insurance claims) between 1988-1998	Very Low: 1; Low: 2-3; Medium: 4-9; High: > 10
Van Heek <i>et al</i> [15], 2005	11.8%	3.8%	< 0.001	Systematic review of studies reporting mortality in 1988 unspecified pancreatic resections in the Dutch Nationwide Registry from 1994-2004	Very Low: < 5; Low: 5-9; Medium: 10-24; High: > 24
Fong <i>et al</i> [4], 2005	8%	2%	0.001	2592 PDs across 1101 hospitals using data from national Medicare database between 1995-1996	Low Volume: ≤ 25; High Volume: > 25
McPhee <i>et al</i> [16], 2007	11.1%	2.7%	< 0.001	39463 pancreatic resections from the US-based National Inpatient Sample Database from 1998-2003 (27289 PDs analyzed separately)	Low: < 5; Medium: 5-18; High: > 18
Riall <i>et al</i> [17], 2007	7.4%	3.0%	< 0.001	3189 pancreatic resections in Texas using the Texas Hospital Inpatient Discharge Public Use Data File from 1999-2004	Low: < 10; High: > 10
Meguid <i>et al</i> [18], 2008	11.1%	5.22%	< 0.001	7558 pancreatic resections from the Nationwide Inpatient Sample from 1998-2003	Low: 1-18; High: > 18;
Billimora <i>et al</i> [8], 2008	15.4%	4.99%	< 0.001	13107 unspecified pancreatectomies in 1454 hospitals <i>via</i> ACS National Cancer Database from 1994-1999	Low: < 2; Medium: 2-9; High: ≥ 10
Balzano <i>et al</i> [19], 2008	12.4%	2.6%	< 0.0001	1576 patients (1044 PDs) from 221 hospitals in Italy using data from Ministry of Health in the year 2003	Low Volume: < 5; Medium: 6-13; High: 14-51; Very High: > 52
Gasper <i>et al</i> [20], 2009	Pooled estimated effects in favour of high-volume hospitals: OR 0.25 (95% CI 0.15-0.41)		< 0.01	5294 patients undergoing pancreatic resections (unspecified) between 1994-2004 from the US-based California Discharge Database	Low: < 5; Medium: 5-49; High: > 50
Teh <i>et al</i> [21], 2009	OR hospital mortality (95%CI) 4.0 (3.1-5.1)	OR hospital mortality (95%CI) 1.7 (1.3-2.4)	< 0.01	103222 patients (76273 PDs) from the Nationwide Inpatient Sample in USA between 1988-2003	Very Low: 3; Low: 3-5; Medium: 6-11; High: 12-23; Very High: 24-35; Extra: > 36
Nathan <i>et al</i> [11], 2009	33.7%	33.5%	0.56	8251 PDs from the State Inpatient Databases for Florida, Maryland, and New York from 1998-2005	Low: < 25; Mid: 25-124; High ≥ 125
Schmidt <i>et al</i> [1], 2010	4%	2%	= 0.04	1003 PDs at Indiana University across two periods 1980-2003 and 2004-2007	Low: < 20; High: > 20
Gooiker <i>et al</i> [22], 2011	Pooled estimated effects in favour of high-volume hospitals: OR 0.32 (95% CI 0.16-0.64)		< 0.001	Metanalysis of 154626 patients across 14 studies undergoing unspecified pancreatic resections from 1970-2010	Pooled volume groups as defined in individual studies; Lowest: 1-5; Highest: 7-36
La Torre <i>et al</i> [10], 2012	2.5%	2.1%	0.66	Systematic literature review of patients undergoing pancreatectomy across 18 studies	Low: 9-8; Medium: 9-12; High: 13-18; Very High: > 19

Alsfasser <i>et al</i> [23], 2012	32.2% (1-yr mortality)	26.2% (1-yr mortality)	< 0.001	9566 patients who underwent PD or total pancreatectomy in Germany from 2006-2009	Low: < 32; High: > 32
Bliss <i>et al</i> [24], 2014	8.1%	3.1%	< 0.001	129609 pancreatectomies from the US based Nationwide Inpatient Sample 2004-2011	Low: < 5; Medium: 5-18; High: > 18; Very High: > 50
Derogar <i>et al</i> [25], 2015	60% greater mortality risk	NR	HR 1.60, 1.04 to 2.48	3298 pancreatic resections from the Swedish National Register (2818 PDs not separately reported) from 1990-2010	≥ 4 (not clearly defined)
Hata <i>et al</i> [26], 2016	Overall pooled OR for mortality in favour of high-volume hospitals: OR 2.37 (95%CI 1.95-2.88)		0.09	Metanalysis of 58023 patients undergoing PD across 13 studies based on nationwide databases from 11 countries	Low: 1-19; Medium: 20-29; High: ≥ 30
Briceno <i>et al</i> [27], 2017	5.5%	2.6%	< 0.001	19024 PDs using the US based National Cancer Database from 2010-2015	Low: < 10; Medium: 10-20; High: > 20 per year
El Amrani <i>et al</i> [28], 2018	4.4%	3.4%	0.047	10632 patients undergoing distal pancreatectomy from 2009-2018 from a national French database	Low Volume: ≤ 10; High Volume: > 10
Krautz <i>et al</i> [29], 2018	10.4%	8.1%	NS	Analysis of 60858 patients undergoing major pancreatic surgery (unspecified) from a German National Database from 2009-2014	Very Low: < 8; Low: 8-18; Medium: 19-31; High: 32-58; Very High: > 59
Balzano <i>et al</i> [30], 2020	8.1%	4.4%	< 0.001	Multicenter study of 7631 PDs (12662 pancreatic resections) in 395 Italian hospitals from 2014-2016	Very Low: 0-10; Low: 10-25; Medium: 25-60; High: 60-166; Very High > 167

NR: Not reported; PD: Pancreatico-duodenectomy; US: United States; ACS: American College of Surgeons; HR: Hazard ratio; OR: Odds ratio; CI: Confidence intervals.

Caribbean where many patients are not able to afford care in developed countries. The region has some of the poorest countries in the Western Hemisphere and many patients in these territories do not have health insurance.

### Data generalization

Healthcare personnel should exercise good judgement when interpreting the available data. Pawlik *et al* [31] made the point that volume-outcome relationships are one way to judge hospitals, but are non-informative about any specific hospital - apart those from which the data was collected. In other words, it cannot be used to generalize outcomes in every low or high-volume hospital. Thus, if a low-volume hospital published data to show good outcomes, it should trump simple volume data.

Additionally, there are many factors that may skew outcomes data: Firstly, within high volume centers, surgeons do not have equivalent experiences, case volumes or clinical outcomes[1,31-34]. Secondly, some high-volume centers may end up treating higher-risk cases while some community or teaching hospitals may treat more indigent patients, potentially skewing outcome data. Thirdly, volume-related data only provides information on patients who underwent PDs, but excludes any useful information on clinician judgement, expertise and decision making when choosing patients for surgery[31]. This critical aspect of care for patients with peri-ampullary carcinomas does not appear in any volume-based data.

### Surgeon volumes

To be able to complete a PD, surgeons must accrue experience through repetition of the operative steps. Some have argued that PD outcomes are less dependent on hospital volume and more dependent on the technical competence of the operating surgeon[1,2,5,7,13,35]. Numerous authors have demonstrated the association between increasing individual surgeon volume and improved PD outcomes[1,2,5,13,35]. Published data show that high-volume surgeons complete PD with significantly lower mean blood loss [1,2], shorter operating time[1] and greater nodal harvest[1] when compared to low-volume surgeons. Nordback *et al*[13] also demonstrated that 86% of post-PD deaths were due to surgical or technical complications.

However, it is difficult to meaningfully interpret these data because there is no standardized definition of a "high-volume surgeon", with researchers applying ad-hoc definitions that range from as low as 3 PDs annually[13] to as high as 50 PDs annually[2,20,30]. We conducted a systematic literature search across the PubMed, Medline and Google Scholar platforms seeking publications that defined: "high-volume" surgeons, using the search terms: "high-volume", "experienced", "subspecialty trained" and "specialized". The literature search was performed by two researchers and spanned the 27-year period from January 1, 1995 to December 31, 2021. Table 2 outlines the results[1,2,3,13,35] and shows a large variation in the definition of "high volume surgeons".

Schmidt *et al*[1] introduced the "experienced surgeon" concept being distinct from a high-volume surgeon. They defined an experienced surgeon as one who had performed > 50 PDs in their career. In other words, they suggested that the cumulative experience was important unlike a high-volume

**Table 2 Summary of studies comparing peri-operative mortality according to surgeon volumes**

Author	Peri-operative mortality		P	Study population	Definition of low-volume surgeon	Definition of high-volume surgeon
	Low volume surgeon, %	High volume surgeon, %				
Lieberman <i>et al</i> [2], 1995	15.5	4.7	< 0.001	2233 PDs over 8 years in New York State	< 9 cases experience	> 41 cases experience
Sosa <i>et al</i> [3], 1998	12	1.8	< 0.001	449 PDs + 47 total pancreatectomies from non-federal facilities in Maryland, USA	< 5 PD annually	> 50 PD annually
Nordback <i>et al</i> [13], 2002	14	3	< 0.05	350 PDs in 33 hospitals by 98 surgeons	< 1 annually	> 3 annually
Schmidt <i>et al</i> [1], 2010	4	2	0.09	1003 PDs at Indiana University across 2 periods	< 20 annually	> 20 PD annually
Eppsteiner <i>et al</i> [35], 2009	6.4	2.4	< 0.0001	3581 pancreatic resections from the National Inpatient Sample Database	< 5 annually	≥ 5 annually

PD: Pancreatico-duodenectomy.

surgeon which was time dependent. Schmidt *et al*[1] were able to demonstrate that, compared to their less-experienced colleagues, experienced surgeons performed more PDs with vein resections (96% *vs* 4%) and had significantly lower overall morbidity, pancreatic leak rates, operative blood loss and mean operating time. Importantly, they showed that experienced surgeons who currently performed PDs at low volumes had equivalent outcomes to high-volume surgeons.

Schmidt *et al*[1] suggested that a pancreatic surgeon needs to accrue 50 PDs before the improvement in technical operative skills begins to plateau. Tseng *et al*[36] suggested that in their experience, surgeons continued to acquire skills and technical expertise even when approaching 200 PDs. Although there is no consensus, and regardless of a time or case-load dependent definition, we believe that pancreatic surgeons continue to gain experience by developing operative maneuvers, recognizing avoidable pitfalls and learning how to get out of trouble when PDs don't go smoothly. They also develop mature judgement that is important for appropriate patient selection. We cannot downplay the importance of developing inter-personal relationships over time that facilitate better working relationships with colleagues in other specialties to enhance supportive post-operative care. These are lessons that can only be learned with proper surgical mentorship and accrued experience[1,37].

### Combined team expertise

Taking it a step further, PDs are quite unforgiving when complications arise. When they do, expert multidisciplinary care is required to prevent bad outcomes[7,37]. This includes input from intensivists, gastroenterologists, interventional radiologists, infectious disease specialists, nutritionists, among others. We agree with Sosa *et al*[3] that it is the "combined experience of the entire team of pancreatic care providers", and not necessarily the hospital volume, surgeon volume or surgeon experience that make the difference in peri-operative outcomes. We also believe that is feasible to foster the growth of a multidisciplinary support team in low-volume institutions.

### Implementation of centralization

Although data accumulated to support centralization, there was reluctance to route patients to high-volume centers, even in the developed countries where data proved better outcomes. Fong *et al*[4] reported that there were only 10-12 high-volume pancreatic surgery centers in the entire United States, but over 1000 Low-volume centers performing PDs. Glasgow and Mulvihill[9] reported that 88% of patients in California had PDs at hospitals that performed < 2 cases per year. Many hospitals continued to perform PDs at low volumes[4,8,9,31,38]. Table 3 outlines the proportion of PDs performed by low-volume hospitals in developed countries.

Similarly, although there were data to support better outcomes by high-volume surgeons[1,2] and experienced surgeons[1], many PDs were not performed by these surgeons. There are numerous examples: Lieberman *et al*[2] documented that 67% of all the resections in New York State were done by low-volume surgeons who had done < 9 PDs; Sosa *et al*[3] showed that 47.3% of PDs in Maryland, USA were performed by low-volume surgeons performing < 1 PD per year; and Nordback *et al*[13] reported that on average, PDs in Finland were performed by surgeons who only performed 2.1/year/hospital and 0.7/year/surgeon.

### Negative effects of centralization

Finally, there is existing data to show that healthcare inequity has developed in hospitals that adopted the centralization principle. There is clear data to show that patients are significantly less likely to have



**Table 3** Proportion of pancreatico-duodenectomies performed outside of high-volume centers

Author	Country	PDs performed by low volume hospital, %	Average surgeon volume	Average hospital volume
Sosa <i>et al</i> [3], 1998	Maryland, United States	47.3	1 per year	1 per year
Riall <i>et al</i> [17], 2007	Texas, United States	36.7	NR	< 5 PD per year
Birkmeyer <i>et al</i> [5], 1999	Medicare database, United States	> 50	NR	< 2 PD per year
Ho <i>et al</i> [7], 2003	Florida and California, United States	77	NR	10% in hospitals doing 1 PD per year
Bliss <i>et al</i> [24], 2014, For period < 2004	Nationwide inpatient sample database, United States	40.8	NR	NR
Bliss <i>et al</i> [24], 2014, For period > 2011	Nationwide inpatient sample database, United States	26.9	NR	NR
Glasgow <i>et al</i> [9], 1996	California, United States	88	NR	< 2 PD per year
Fong <i>et al</i> [4], 2005	National Medicare Database, United States	89	1 per year	1 PD per year

PD: Pancreatico-duodenectomy; NR: Not reported.

PD in a high-volume center if they are non-white (Table 4)[3,16,17,24,39], female[17] or did not have private insurers (Table 5)[24]. Eppsteiner *et al*[35] also documented that across the United States, patients were significantly more likely to have their pancreatic resections by high-volume surgeons if they were male, white raced, and a resident of a high-income zip code.

## CARIBBEAN EXPERIENCE

The age standardized incidence of pancreatic adenocarcinoma in the Caribbean is 4.4 per 100000 population[40]. However, only 3 of 17 Caribbean countries have populations > 200000 persons. Therefore, few patients develop peri-ampullary lesions and qualify for PD annually. Peri-ampullary malignancies remain the most common indication for PD in the Caribbean, but most patients are not able to access high-volume centers in developed countries because of travel restrictions, lack of social support, financial limitations and/or lack of health insurance. Therefore, local hospitals are often their only options for PD.

After three specialized HPB centers were established in the Caribbean in 2011, general surgeons readily gave up performing major hepatectomies but they have been reluctant to give up PDs. We previously reported that 98% of hepatectomies are now performed by subspecialty trained HPB surgeons[41], but a review of unpublished data from the same database between 2013 and 2020 showed that 80% of attempted PDs were performed by HPB teams (Table 6).

As a surrogate marker of technical expertise, we used the same database to tally the number patients who had PD attempted and those who had PDs completed. The HPB surgeons completed 94% of attempted PDs, but general surgeons performed palliative bypasses in all 18 cases. Schmidt *et al*[1] suggested that vein reconstruction was a surrogate marker for surgeon experience. In this database, HPB surgeons were more likely to perform vein reconstruction during PD compared to general surgeons (26% *vs* 0). This suggests that the specialty surgeons were experienced, although none were high-volume surgeons using conventional criteria in Table 1. Published data documented that only 12.8 PDs were performed annually at the busiest specialized HPB center in the Caribbean[42]. Nevertheless, we believe that outcomes can be improved using a modified centralization concept, with attention to the following five points.

### Leadership

Surgical leaders must recognize that the concept of centralization is a significant deviation from "cultural norms" in the Caribbean and general surgeons are bound to resist this change. We must also recognize that it is not feasible to send all patients across the region to referral centers. Even if this was feasible, it would be undesirable because it would develop services in a handful of institutions but it would not be beneficial to the entire population at large.

Therefore, an astute leader could instead offer to operate at lower-volume centers assisted by general surgeons. In this way, they could identify and change hospital-based practices and processes. This has several potential advantages: better trained staff, diligence in care administration, development of critical care pathways and improved proficiency of the less experienced facility and their staff to care for

**Table 4 Patients undergoing pancreatico-duodenectomy at high-volume centers (%)**

Parameter	Data source	Whites, %	Non-whites, %	P
Sosa <i>et al</i> [3], 1998	Non-federal facilities in Maryland, United States	25.2	9.8	< 0.001
McPhee <i>et al</i> [16], 2007	National Inpatient Sample Database, United States	80	20	NS
Bliss <i>et al</i> [24], 2014	National Inpatient Sample Database, United States	65.6	34.4	0.018
Eppsteiner <i>et al</i> [35], 2009	National Inpatient Sample Database, United States	79.3	20.7	NS

PD: Pancreatico-duodenectomy; NS: Not specified.

**Table 5 Patients undergoing pancreatico-duodenectomy with private insurance coverage (%)**

Parameter	Data source	High-volume center, %	Low-volume center, %	P
Bliss <i>et al</i> [24], 2014	6144 patients undergoing PD	43.7	36.9	< 0.001

PD: Pancreatico-duodenectomy.

**Table 6 A comparison of outcomes in 90 patients undergoing pancreatico-duodenectomy in a Caribbean centre**

Parameter	Sub-specialty surgeon, (%)	General surgeon, (%)	P
Attempted PD	72/90 (80)	18 (20)	< 0.0001 <sup>Z</sup>
Completed PD	68/72 (94)	0	< 0.0001 <sup>F</sup>
Portal vein resection/reconstruction	19/72 (26)	0	0.0103 <sup>F</sup>

<sup>F</sup>Statistical analysis using Fishers Exact Test.

<sup>Z</sup>Statistical analysis using Z-test for Proportions.

PD: Pancreatico-duodenectomy.

critical patients. We agree with Pawlik *et al*[31], Billimora *et al*[8], Gasper *et al*[20], Hashimoto *et al*[43] and Ravaoli *et al*[55] that we should strive to identify specific elements of patient care in specialized hospitals that lead to better outcomes and introduce them in less-experienced facilities.

### **Fostering team spirit**

We have already made the point that PDs are technically complex and unforgiving operations. Complications will occur once sufficient cases are attempted - and, regardless of surgeon skill and experience, it is the multidisciplinary team effort that will save patients. Therefore, it is important to pay attention to the pre- and post-operative care pathways.

Before selecting a patient for PD, there should be rigorous pre-operative evaluation[8,44,45], medical optimization[8], anaesthetic assessment[8,44] and tumour board discussion[46]. Mature surgeon judgment also has a large impact on the patient that makes it to the operating table. All of these factors affect peri-operative outcomes.

When complications develop in the post-operative phase, it is often not the surgeon who comes to the rescue. They rely on multidisciplinary support from a variety of specialties for around-the-clock emergency care[8,47-51]. It goes without saying that these services should be developed concurrently and we should strive for good interpersonal relationships across disciplines.

### **Critical assessment of the healthcare environment**

It is clear that the healthcare environment in the Caribbean differs significantly from those in developed countries. We have provided data showing that local subspecialty surgeons are experienced, but they have repatriated to resource-poor settings with many challenges: scarce blood products, lack of readily available specialized equipment, high competition for ICU/HDU beds, an undersupply of consumables and infrequent operating lists.

One is forced to realize that the environment is not always conducive to observing best practice recommendations[41]. In order to maintain quality service delivery, surgeons must perform a critical appraisal of their local facility and understand the pitfalls in their environment. Tailored processes of care would then have to be devised that suit the local healthcare environment. We agree with Sosa *et al*

[3] who suggested that, instead of focusing on transforming a facility to a high-volume hospital, effort would be better spent on developing a systematic approach to handle these patients by developing critical pathways to enhance the performance of the entire health care delivery team.

### **Developing partnerships**

While the traditional concept of centralization according to hospital volume or surgeon experience may not be practical in the Anglophone Caribbean, we have seen improved outcomes after introducing a partnership concept. In this concept, patients need not be channeled solely to referral centers. Instead, most Caribbean countries are sufficiently small for staff to move from referral centers to less experienced facilities, bringing with them experience, knowledge and select equipment for safe operations to be performed. Similarly, Ravaioli *et al*[52] published data to show that their institutions benefited from partnerships between high and low-volume facilities.

With this approach, we found that general surgeons still felt useful and were willing to cooperate with sub-specialists. They benefited because they received oversight from subspecialty surgeons, felt empowered to communicate about complications and increased their skillsets. Other authors have made similar suggestions to transfer mechanisms to improve outcomes into lower-volume hospitals where most patients receive their care[8,31,52].

### **Regular audit**

Over the years that the HPB units have been implemented in the Caribbean setting, we have prioritized data collection because we recognize that this is the way to objectively evaluate our clinical practices. The value of this exercise ultimately lies in improvement in outcomes after PD for the population as a whole, but changes in outcomes will not be fully evident until regular audits are carried out. This is the only way to create tangible benefits for the healthcare system. Regular review of the data also allows us to better understand the challenges in the local healthcare system, ultimately facilitating the development of clinical care pathways and effective use of limited resources.

### **Knowledge of population based data**

It is important for surgeons to be knowledgeable about the characteristics of the population they work with. For example, it has been shown that persons of Caribbean descent harbor greater-than expected HPB anatomic variations[53]. If a surgeon has not anticipated and/or identified these variants, they can be easily injured and create significant complications. An example is a replaced right hepatic artery coursing behind the pancreatic head. This is prone to injury during PD and can lead to hepatic ischemia and mortality. In Caribbean populations, a replaced right hepatic artery coursing behind the pancreatic head is present in 18% of unselected individuals - significantly greater than published reports in medical literature[53].

Ultimately, there seems to be emerging consensus in the recent medical literature that hospital volume, surgeon volume and hospital teaching status are only proxies for not-yet-fully understood processes of care delivery[52,54,55]. These vary between facilities, but include staffing level, tumour board meetings, surgeon skill, care pathways, available technology and support services. Instead of focusing on these proxies, physicians should focus on specific hospital-based outcomes data and find directed ways to improve the quality of care in your hospital despite volume, surgeon, teaching or financial status of the facility.

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## **CONCLUSION**

Despite low case volumes, cultural resistance to subspecialty care, financial barriers and resource-poor environments, we have been able to maintain acceptable short-term outcomes after PDs. We advocate developing an intimate knowledge of your health care system to identify processes that will facilitate good outcomes. In our setting we used a modified centralization concept, with attention to creating partnerships with experienced staff, fostering teamwork, appropriate staff training, development of care pathways, regular audits and knowledge of population-based data.

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## **FOOTNOTES**

**Author contributions:** Cawich SO, Naraynsingh V, Deshpande R and Shukla P designed and coordinated the study; Pearce NW, Deshpande R, Shukla and Naraynsingh V acquired and analyzed data; Cawich SO, Naraynsingh V, Deshpande R and Shukla P and Pearce NW interpreted the data; Cawich SO, Naraynsingh V, Deshpande R and Shukla P and Pearce NW wrote the manuscript; all authors approved the final version of the article.

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